SCIENCE TEACHER'S WORLD

Teacher's edition of Science World • March 10, 1959

'Selling' science in assembly programs

An excellent way to stimulate interest in the study of science is through school assembly programs. In planning how to present science in such programs, start from the assumption that the students aren't interested in science as such — that the material used must be fascinating in itself. Whenever possible, students themselves should participate. And, don't forget, a liberal dose of showmanship will help put the program across. The following are some ideas that may be helpful.

The "spectacular." Some demonstrations are almost sure bets as interest arousers. One of the most spectacular is the Thermit demonstration. Proceed as follows:

Set up apparatus as shown, using three very small nested red-clay flowerpots. Close the drain hole at the bottom of the smallest and topmost flowerpot with a small piece of paper. Add two ounces (*but no more*) of Thermit (you can prepare your own by mixing approximately equal amounts of iron oxide powder and aluminum powder). Place the flowerpots in a tripod resting in a heavy metal basin containing at least six inches of dry sand. Then place magnesium ribbon into the mixture. Protect the auditorium stage with asbestos blankets or asbestos sheets.

Ignite the ribbon with a match and step back quickly. At the same time, have someone darken the auditorium. A brilliant reaction will take place, giving off tremendous quantities of blue-white light. Then a molten mass of iron will pour through the holes of the flowerpots into the sand. Use tongs to pick up the red-hot mass of iron. (Do not touch it, of course, until it is completely cold.) What happened: when the aluminum combined with the oxygen in the iron oxide, it reduced the iron oxide to iron.

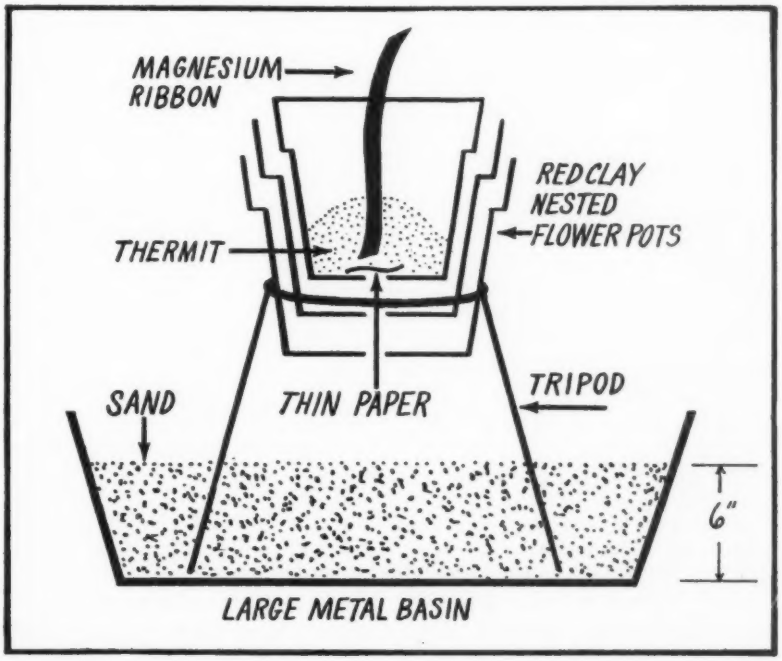
You undoubtedly have ideas of your own about demonstrations suitable for use in assemblies. You will find other good possibilities from time to time in the "How to Do It" section of this magazine.

"Come to the fair." To generate interest in a science fair, have students demonstrate and explain prize-winning exhibits of the past year. Naturally, it's best to use projects that are large enough to be visible to the audience.

"They all laughed at . . ." Don't overlook the historical approach, dealing with inventions or discoveries that were once deemed impossible — the telegraph, the telephone, and the wireless, for instance. People laughed at the attempts to develop these. For dramatic impact, have students dress in period costumes and operate the appropriate equipment. For the wireless demonstration, use an ordinary induction coil with a spark gap across the secondary, or use a buzzer. Pick up the signal with an ordinary radio. In this way, the entire audience will hear the signal.

Reports from shutterbugs. Color slides of scientific subjects taken by students or teachers can make for an interesting program. The slides might include geological scenes, steel mills, laboratories, exhibits at science fairs, etc. Motion pictures,

— Drawing by LoCurcio



STW Contributing Editors: Alexander Joseph, Zachariah Subarsky

of course, are even better. Since most schools do not have 8-mm. projectors (8 mm. is the film width usually used for home movies), it may be necessary to borrow a good 8-mm. projector from a parent or a friend.

A word of warning: edit the pictures carefully, and use only those that tell an interesting story.

Films and other material of use in science assembly programs are also available from such companies as Bell Telephone and General Motors. Be sure not to use standard science instruction films.

Their best foot forward. When science students do something of special interest in the way of investigations, research, or original projects, it's a good policy to bring this to the attention of their classmates during assembly. If a student has won a science award or has had his project published (in SCIENCE WORLD, for instance), the presentation or announcement can be made in the assembly. One precaution: keep the announcement or presentation short; it should last no more than ten minutes.

If students need to show diagrams to illustrate their investigations or projects, they can use the techniques of non-photographic slide-making described in "Audio-visual Aids in the Science Classroom," January 20 *STW*.

Stimulating speakers. Local laboratories, technical industries, health departments, and colleges and universities can often provide speakers on scientific subjects. But it is important to determine whether or not the person who speaks is sufficiently vital and interesting to maintain the interest of the students. Local Air Force bases and Naval air stations often offer stimulating speakers on aviation and space flight.

One final note: whatever the program, it should be rehearsed, if possible, to see that it stays within the time limit, to prune out dull material, and to give it a fast, smooth pace. — ALEXANDER JOSEPH

Science teacher's question box

How can I make my own Fehling's solution? — W. F., Los Angeles, Calif.

Two solutions are mixed to make Fehling's solution just before it is used. Solution one is made by dissolving 34.65 grams of copper sulfate in 500 cc. of water. Solution two is 125 grams of potassium hydroxide and 173 grams of potassium tartrate dissolved in 500 cc. of water. (*Warning: do not handle potassium hydroxide with the hands, since it is very caustic.*)

How can I make aquarium cement that will seal leaking fish tanks? — J. P., Orange, N. J.

First empty and thoroughly clean the tank, eliminating all rust. Allow the tank to become completely dry. Then make a cement of 10 ounces of litharge, 10 ounces of plaster of Paris, 1 ounce of powdered rosin, and 10 ounces of boiled linseed oil. Mix the dry ingredients, and then dissolve in the linseed oil. Work into all crevices with a spatula or knife. Allow four days to set.

How can I grow, in the classroom, plants that thrive in acid soil? — H. S., Arcadia, Calif.

Mix 26 parts of ammonium sulfate, 31 parts of superphosphate fertilizer, and 190 parts of potash with redwood or cypress sawdust. Then mix this with equal parts of ordinary garden loam. The plants should grow well in this.

How can I make glass-to-metal seals without melting the glass? — D. G., West Palm Beach, Fla.

Use sodium silicate (water glass). In the case of tubing, wrap it with porous paper and soak the paper in silicate. The paper acts as a gasket.

How can I make a solution that will keep a frog's heart beating for several hours? — R. M., New York, N. Y.

The solution is called Ringer's solution. A special kind of Ringer's solution is used for frog's hearts. To make it, dissolve .14 grams of potassium chloride, 6.5 grams of sodium chloride, and .12 grams of calcium chloride in 1,000 cc. of water.

What is a simple way to show that green plants take in carbon dioxide? — S. A., Atlanta, Ga.

Prepare a solution of bromothymol blue, diluted until it is light blue in color. Blow through a drinking straw into the solution in order to get carbon dioxide into it. The bromothymol blue will change to yellow. Now pour the solution into two large test tubes. To one test tube, add a fresh sprig of a green water plant such as *Elodea*. Place both tubes in sunlight. After fifteen minutes to one hour in sunlight, the bromothymol blue in which the plant is resting will turn back to blue. During photosynthesis, the plant has taken in the carbon dioxide blown into the solution. The control, in the other tube, remains yellow.

Is there any scientific explanation for the seemingly successful location of underground water by so-called water witching? — J. V. S., Marion, Ohio

No. For an extensive treatment of this question, see Supply Booklet 416 (1938), U.S. Geological Survey, by Arthur J. Ellis. The title of this booklet is *The Divining Rod — a History of Water Witching*. It contains a bibliography arranged in chronological order dating back to the early sixteenth century.

A more condensed discussion of this question may be found in the 1955 Yearbook of Agriculture, U.S. Department of Agriculture. See the essay, "The Age-old Dispute about a Forked Stick," by Arthur M. Sowder, Extension Forester of the United States Department of Agriculture.

MEMO

To: Science teachers

Subject: Ways to use this issue of SCIENCE WORLD in the classroom

Bright forecast for weather

PHYSICS TOPICS: atmospheric pressure, computers, radio
EARTH AND GENERAL SCIENCE TOPICS: weather, weather instruments, forecasting

This article gives the reader an up-to-date, over-all view of the present state of the art of weather forecasting. In addition to learning about weather instruments, students will get an idea of the theories concerning the air circulation of the globe and the weather it produces. They will get an insight into the relationship of lows, highs, cold fronts, and warm fronts, and into how this relationship affects weather and weather forecasting. They will learn of the great difficulties of controlling weather and of the very limited circumstances under which cloud-seeding experiments can be applied.

Class discussion

1. Why do scientists make it clear that they cannot promise too much in the way of future weather control?
2. What is the relationship of lows and highs to weather?
3. How do cold and warm fronts affect our weather?
4. What are some of the methods now being used by meteorologists to gather high-altitude weather information?
5. What is "spring fever"?

Class activities

1. Build and operate a class weather station.
2. Have students watch "The Unchained Goddess" on NBC-TV, Sunday, March 22.
3. Have students keep a record of daily weather forecasts and compare them with the actual weather for a period of four weeks.

When dinner is served in space

BIOLOGY TOPICS: nutrients, metabolism
GENERAL SCIENCE TOPIC: food

This imaginative article combines the fascinating subject of space flight with an excellent biochemical review of the human body's fundamental nutritional needs. Since the author is a biochemist with years of college-teaching experience, he brings a good deal of authority to bear on the subject. Biology and general science students might well clip the article and add it to their notebooks or textbooks to round out the topic of nutrition.

Class discussion

1. What would be the minimum daily needs of each member of a human space crew?
2. Why are other foods besides carbohydrates necessary?
3. Which food packs the most calories in the least weight and space?
4. Why are proteins one of the better all-around space foods?

Class activities

1. Make up food samples in the proper quantities to show the minimal daily nutritional requirements in a spaceship.
2. Make up a sample food pill for space travel, using real nutrients.

Insects as hunters and trappers

BIOLOGY TOPICS: insects, nervous system
GENERAL SCIENCE TOPICS: food-getting activities of insects, the insect world

In biology classes, students meet insects in the survey of the animal kingdom and in the study of pollination and the transmission of some diseases. Rarely will they find such a thorough treatment of the activities of insects as is presented

in this article. For general science students, the teacher can suggest that their attention be directed to the food-getting methods of the insects. Students will be particularly interested in the compound eyes and the communications and weapons systems of insects. Another fascinating aspect presented by the article is the physical strength of insects.

Class discussion

1. How can an insect lift many times its own weight?
2. What is the advantage to insects of a multiple-lens eye?
3. What are the hunting methods of different insects?
4. How do insects compare to humans in their response to sound?
5. What are the weapons in the arsenal of insects?

Class activities

1. Make a display of dead insects to illustrate the types of hunters described in the article.
2. Examine a fly's eye under a microscope.
3. Examine an insect's wings under a microscope.

Camera in the science lab

PHYSICS TOPIC: laboratory work
GENERAL SCIENCE TOPIC: photography

This article may motivate science students to use their cameras in class or laboratory work. In addition to the use of a camera, the article describes non-camera techniques, using photographic paper, that students can carry on in class.

Class discussion

1. What are the different ways in which photography may be used in the school laboratory or in science classwork?
2. How can photographic images be made without a camera?

Class activities

1. Have students perform some of the activities outlined in the article.
2. If possible, borrow a Polaroid camera and use it to take pictures that can be printed immediately.
3. Use a simple slotted disk, turned by a small motor, as a stroboscope. Place it in front of the lens of a camera and, with the shutter open, photograph the free fall of a ball. The picture will show the positions of the ball during its fall, as determined by the constant acceleration of gravity.

QU-I-I-I-ET!

PHYSICS TOPICS: acoustics, soundproofing
GENERAL SCIENCE TOPICS: sound, silencing sound, reactions to sound

Here is an article that expands on the information on sound usually covered in physics and general science classes. Not only is there a review of the nature of sound, but also an introduction to practical acoustical principles. Many important conceptual terms of modern acoustics are developed in an easy-going, straightforward manner. The article can serve to extend and enrich classwork on sound.

Class discussion

1. What are the kinds of problems that sound engineers face?
2. Why are certain sounds "unnecessary"?
3. What is the difference between noise and music?
4. What is the nature of sound transmission?
5. What is frequency?
6. How is volume of sound determined?
7. What kinds of sounds are most annoying?

Class activities

1. Demonstrate sound waves by speaking into a microphone that is connected into the input of a cathode-ray oscilloscope.
2. Demonstrate tuning forks of different fundamental frequencies.
3. Demonstrate the ability of sound to travel through a solid by using an eight-foot stick or rod to listen to the ticking of a watch.

Venture to the moon

PHYSICS TOPICS: atmospheric pressure, gravity
GENERAL SCIENCE TOPICS: the moon, spaceships

This is another of the science fiction stories that can contribute greatly toward creating classroom interest in science. It presents an imaginary landing on the moon of spaceships from several different nations. From the story, students can learn something about day and night on the moon, the moon's difficult terrain, the logistical problems of such a venture, and the effect of low gravitational forces upon sports and everyday activities. This is a story that does not in any way violate scientific principles, in spite of the almost realistic "reporting" done in the story.

Class discussion

1. As a result of the moon's weak gravitational pull, what would be the problems connected with small moving objects just above the moon's surface?
2. How would men on the moon be supplied?
3. What would happen to a golf ball or baseball if it were hit on the moon?

Class activities

1. Build a model of a lunar spaceship.
2. Post photographs of lunar probes on the bulletin boards.

YOUNG SCIENTISTS

Teachers are urged to have their students submit write-ups of interesting projects or experiments they have done. If printed in SCIENCE WORLD, full credit will be given to the student, the school, and the teacher. In addition, the student will receive $15. Contributions should be addressed to Science Project Editor, Science World, 575 Madison Avenue, New York 22, N.Y. Students should be reminded that by submitting their ideas they can do a service to thousands of other students.

MARCH 10, 1959

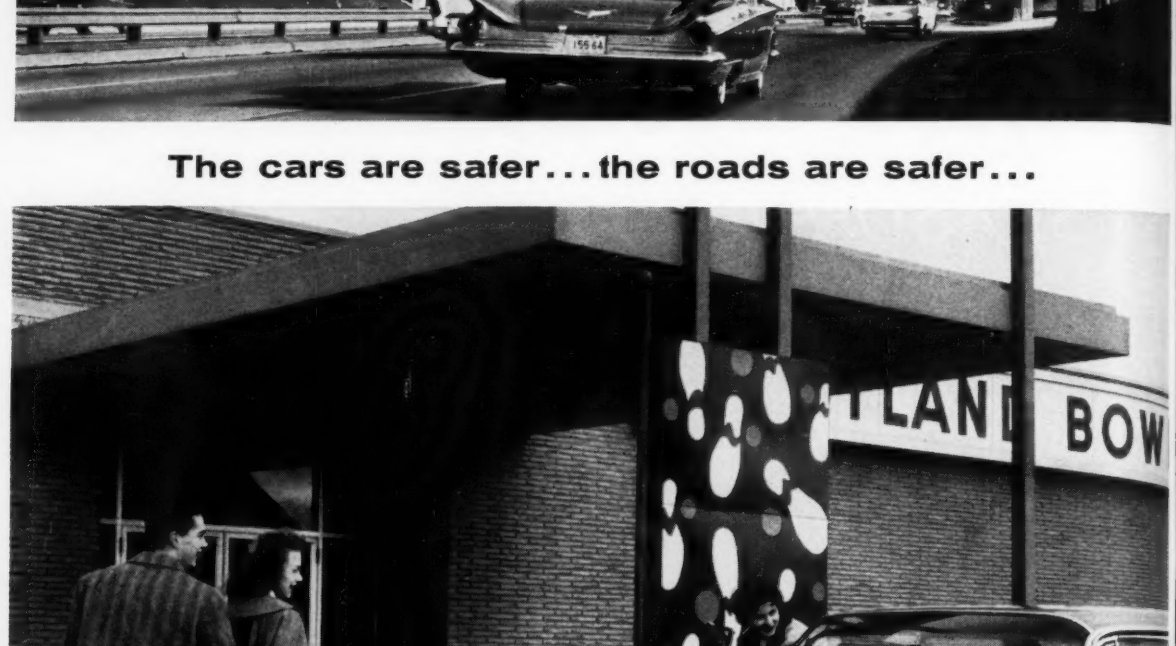
SCIENCE WORLD

THE SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS

TORNADO SEASON AHEAD

(see page 3)

The cars are safer... the roads are safer...



THE REST IS UP TO YOU!

Safe driving is fun. And it got that way through the efforts of three groups of people—the automotive manufacturer, the traffic expert, and the safe driver.

The automotive industry contributes such things as power brakes, safer tires, safety *plate* glass, and sealed beam headlights. The highway and traffic authorities give us divided highways, overpasses and efficient traffic light systems, among other things.

The rest of the responsibility is squarely on the shoulders of the driver. That's you! If you are a safe driver your contribution is courtesy, alertness, caution, and a respect for the rights of others. If you're not a safe driver you can't honestly expect to enjoy the privilege and fun of driving, can you? So play it smart, play it safe—you'll enjoy driving more, and have more opportunity to drive if you do.

GENERAL MOTORS A CAR IS A BIG RESPONSIBILITY—SO HANDLE WITH CARE!

Science Words is published biweekly during the school year, September through May inclusive (18 issues per semester, 16 issues per school year), except during school holidays and at mid-term by Street & Smith Publications, Inc., 575 Madison Avenue, New York 22, N.Y. Second-class postage paid at New York, N.Y., and at additional mailing offices. © 1959 by Street & Smith Publications, Inc., in the United States. Subscriptions, U.S.: $1.00 per semester (8 issues); two semesters (16 issues) $1.50; single copy, 15¢. Back copies, 25¢. Canadian subscription rates are the same as United States; additional postage for countries in Pan American Union: one semester, $1.00, two semesters,

SCIENCE WORLD

THE SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS

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Coming in SW, March 24

Do earthworms have brains?

How will spacemen be supplied with food and air on trips that will keep them away from Earth for years?

In what ways can atomic explosions be used for peaceful purposes?

When any semi-conducting crystal is heated, it glows even before it becomes red hot. How can this phenomenon date events that occurred millions of years ago?

For answers, see next issue of *SW*.

Meanwhile, drive safely!

SCIENCE WORLD is published biweekly during the school year, September through May inclusive (16 issues per semester, 16 issues per school year), except during school holidays and at mid-term by Street & Smith Publications, Inc., 575 Madison Avenue, New York 22, N.Y. Second-class postage paid at New York, N.Y., and at additional mailing offices. © 1959 by Street & Smith Publications, Inc., in the United States. Subscriptions, U.S.: $1.00 per semester (16 issues); two-semester subscription (16 issues), $1.50; single copy, 15¢. Back copies, 25¢. Canadian subscription rates are the same as United States; additional postage for countries in Pan American Union: one semester, $1.00, two semester, $2.00; cost of additional postage for other foreign countries: one semester, $1.50, two semesters, $3.00. Address all subscription mail to Science World, 304 East 45 Street, New York 17, N.Y. Send notice of undelivered copies on form 3579 to: Science World, McCall Street, Dayton 1, Ohio.

Printed in U.S.A. 24

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Cover by Peter Burchard

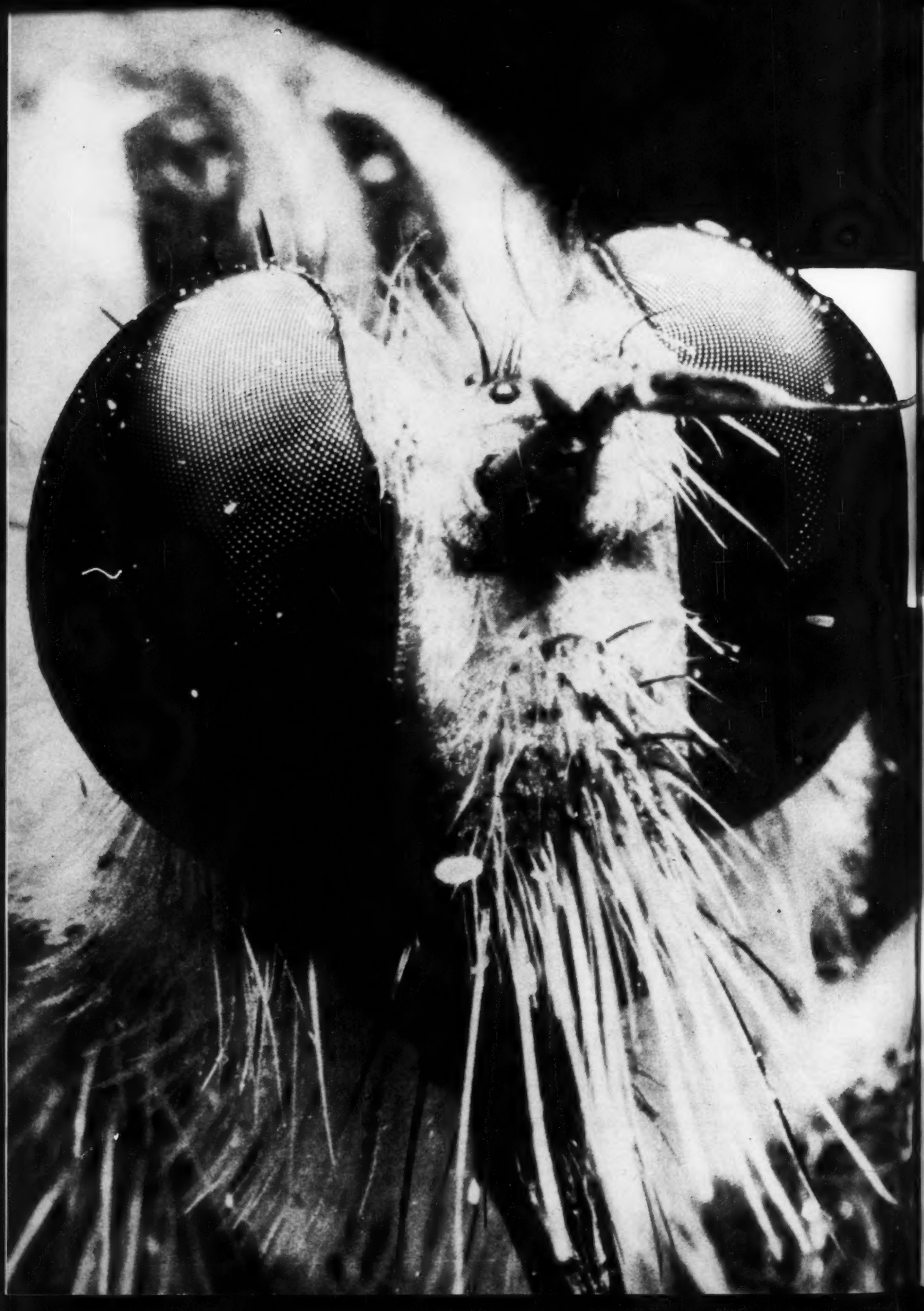
Cover story

The lowering black clouds and curving funnel of a tornado are a terrifying sight, for tornadoes are among the most devastating storms to strike this country. Fortunately, science is making progress against them.

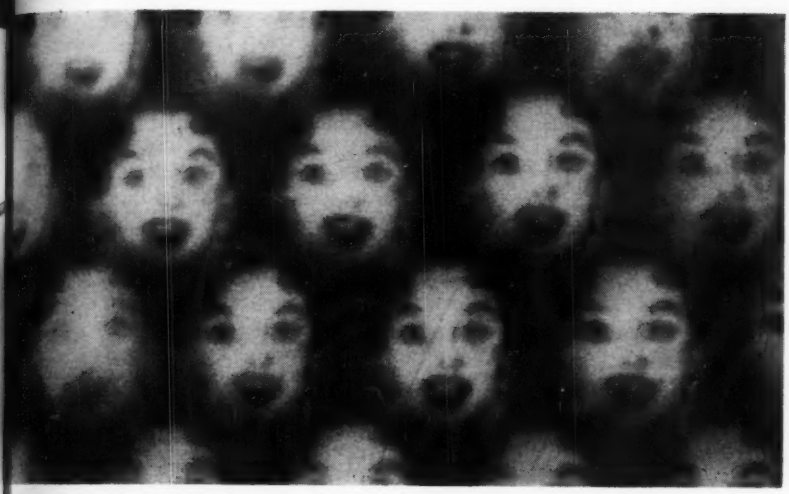
Item 1: The U.S. Weather Bureau is progressing in the difficult job of forecasting tornadoes, with the result that those in the storm's path often have warning. Not long ago, 38 tornadoes struck in one day. Only three were outside their predicted areas.

Item 2: Weather Bureau scientists have learned a great deal about how and why tornadoes occur. The cause: a precise combination of several weather conditions. Cool dry air moving over warm moist air, with a band of strong wind high above the ground, can set up a vortex (whirl) several thousand feet above the ground. As this grows, it reaches toward the ground and can be recognized by its dark, funnel-shaped cloud. Inside the funnel is a vacuum so powerful that it turns buildings into exploding bombs. Tornadoes strike in all seasons, but chiefly during April-June. Six states — Kansas, Texas, Oklahoma, Iowa, Missouri, and Arkansas — are the chief victims.

For more on weather, see page 12.



Eyes of most insects, like those of robber fly at left, consist of thousands of tiny eyes. Each lens forms a separate image, as shown below in photo of girl taken through an insect's eye. *Life size of fly: ¾ inch long.*



Insects as hunters and trappers

By Ross E. Hutchins

■ Many thousands of years ago, cave men used spears to hunt game. Later they invented the bow and arrow, and still later these Stone-Age men found that arrows were more effective if they were treated with poison. Others of these remote ancestors of ours invented pitfalls and snares to capture game for the pot.

Usually, we think of these hunting and trapping methods as being very ancient, but we do not stop to think that nearly all of them were actually used long before man even appeared upon the stage of life. Unknowingly, these cave-men relatives of ours were merely employing methods that had been used by insects since the time when the modern world was very young and when the seas still rolled over much of what is now the United States.

Thus, the wasps used poison darts to paralyze prey, the caddisfly young employed silken snares to capture small aquatic creatures, and the ant lions and worm lions built their pitfalls in the sand to catch unwary ants and other small insects.

Long before man existed, there were also trappers. Young tiger beetles dug their holes in the earth and "set" their traplike jaws for passing game, and ambush bugs hid in flowers and trapped bees and other insects that came seeking nectar. There were then, as now, hunting insects, such as water scorpions, that stalked their prey among the vegetation beneath the surfaces of ponds and streams.

These hunters and trappers of the insect world are extremely well equipped for their trades, but the weapons and tools that they use are actually various body parts that have been modified by nature to do specific jobs. For example, humans have often used spears for defense, but insects have "built-in" spears that we call stings. Most all of their tools are very efficient, but this is because nature has been changing and improving them for millions of insect generations. These tools and insect weapons are as follows.

Senses

Keen senses are important to all hunters and trappers, and the insects are well endowed in this respect. For example, their sense of smell is far more efficient than that of a bloodhound. Strangely, the organs of smell are not always located on the head, but on various other parts of the body — even on the feet.

In many insects the sense of hearing is also well developed. This is especially true with the grasshoppers and katydids. But you will be surprised to learn where their ears are located. In the case of the katydids and their relatives the ears are on the front elbows, but grasshoppers have theirs on the sides of the abdomen just behind the back legs. Other insects have hearing organs located on various other parts of their bodies.

Any creature that hunts for a living usually needs keen vision, whether it be man, insect, or tiger.

Photos and text from Insects — Hunters and Trappers, *by Ross E. Hutchins. Copyright 1957 by Ross E. Hutchins. Reprinted by permission of Rand McNally & Company, publishers.*

Insects' eyes are far different from ours, since they consist of many tiny, individual units, each with its own lens. The eyes are known as *compound eyes* and are often made up of thousands of individual eyes. The eyes of dragonflies, for example, have some 25,000 such units.

It is difficult for us to tell what objects really look like to an insect, even though we can actually take photographs through the lenses of their compound eyes. Do insects see thousands of separate pictures of the same thing, or does each eye see only a portion of an object? The latter is probably what really occurs, and we call this *mosiac vision*. Insects' eyes are believed to be especially effective for detecting moving objects. That's the reason it is so difficult to sneak up on a fly.

While we can say that, in general, the hunting insects have very good vision and are alert to every movement, yet there are exceptions. The cicada killer hunts the cicada chiefly by its sound; and the greatest of all hunting insects, the driver ants of the tropics, are blind. Apparently they hunt by scent like foxhounds.

Weapons

Probably the most useful weapons possessed by insects are the mandibles, or jaws, which work sidewise instead of up and down; and they use these implements for almost every conceivable purpose. Earth-dwelling kinds use them to dig with; but the hunters, such as the tiger beetles, have relatively large, toothed jaws for capturing game. Other insects, such as the ant lions, have mandibles like hollow hypodermic needles through which they can inject poisons into their prey and later extract the body fluids.

In still other insects, such as the assassin bug and giant water bug, the mandibles and other mouth parts are modified into a single piercing beak that is used to extract the blood of prey.

One of the most interesting adaptations for capturing prey is that of the dragonfly young. In this case, the "lower lip" has been modified by nature into a grasping organ that can be flipped out to grab tiny creatures. This may sound rather amazing until we remember that an elephant uses its nose to pick up food.

The legs of insects, too, are often modified to serve as weapons. Outstanding examples are the terrible grasping forelegs of the praying mantis and the giant water bugs. The mantis is able to capture large, strong insects with its front legs and to hold them as we do ears of corn.

Many insects who live by preying on other insects are winged and pursue their prey from the air, as in the case of the dragonflies. But there are a few that rely upon fast-running legs to obtain their dinners; for instance, the beautiful, metallic, fiery hunter beetle regularly captures its food on foot.

Of all the interesting ways that the body parts of insects have been modified to do specific jobs, those involving the egg-laying apparatus are probably the most interesting. The most effective weapons ever used by any small creature are the poison stings of the wasps and bees. With these instruments wasps can kill or paralyze their spider and insect prey and can effectively defend themselves against nearly all enemies, including man. Strangely, these poison darts with their needle-like tips are really modified ovipositors, or egg-laying organs.

Not much information is available about the composition of wasp and hornet venom, but the venom of honeybees has been studied extensively. It is a clear fluid with an acid reaction and a bitter taste. A small amount of formic acid is present, but the important thing is about 1 per cent of histamine. The visible reactions — swelling, hives, and itching — are due to this latter substance. It is probable that other bees and wasps have a similar kind of poison, but the hunting wasps that paralyze their spider and insect prey apparently have also a nerve poison.

It is interesting to know that certain native tribes in the Amazon region of South America also make use of poison darts to capture game. These darts are tipped with curare, a peculiar drug obtained from a plant. It causes paralysis of the game, just as the sting of a wasp does with its spider or insect game.

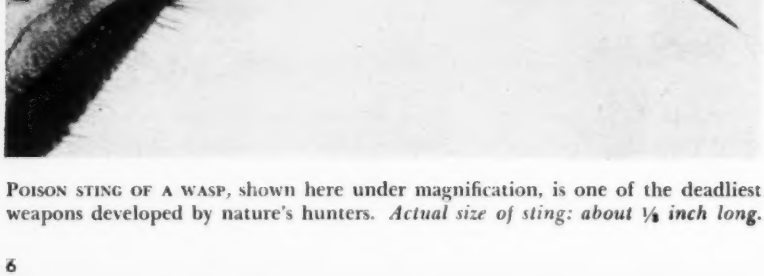
But nature was not satisfied with making poison stings out of ovipositors; she went a step further in the case of a good many parasitic wasps. Suppose such a wasp wishes to lay its egg on the grub (worm-like larva) of a wood-boring beetle, deep in the solid wood of an oak tree. This would seem hopeless, but nature has modified the egg-laying equipment of the wasp into an effective drill that can bore down through the solid wood and lay an egg on the hidden grub. How does the wasp know the grub is there? Only the wasp knows the answer to that.

Wings

Any creature that flies has a tremendous advantage over one that does not. The hawk drops down out of the sky and fastens its talons in the earthbound chicken, and the crawling caterpillar is helpless against the hunting tiger beetle and the wasp. The dragonfly skims over the surfaces of ponds capturing small insects on the wing.

But insects did not always have wings. Many aeons ago the insects

— Photos by the author



POISON STING OF A WASP, shown here under magnification, is one of the deadliest weapons developed by nature's hunters. *Actual size of sting: about ⅛ inch long.*

all crawled upon the earth as did all other creatures of that time. As the ages passed, however, some kinds of insects developed lateral expansions along the sides of their bodies that were probably used to help them sail from tree to tree like flying squirrels. In time, nature imparted motion to these expansions, and powered flight became a reality for the first time on this planet.

Strength

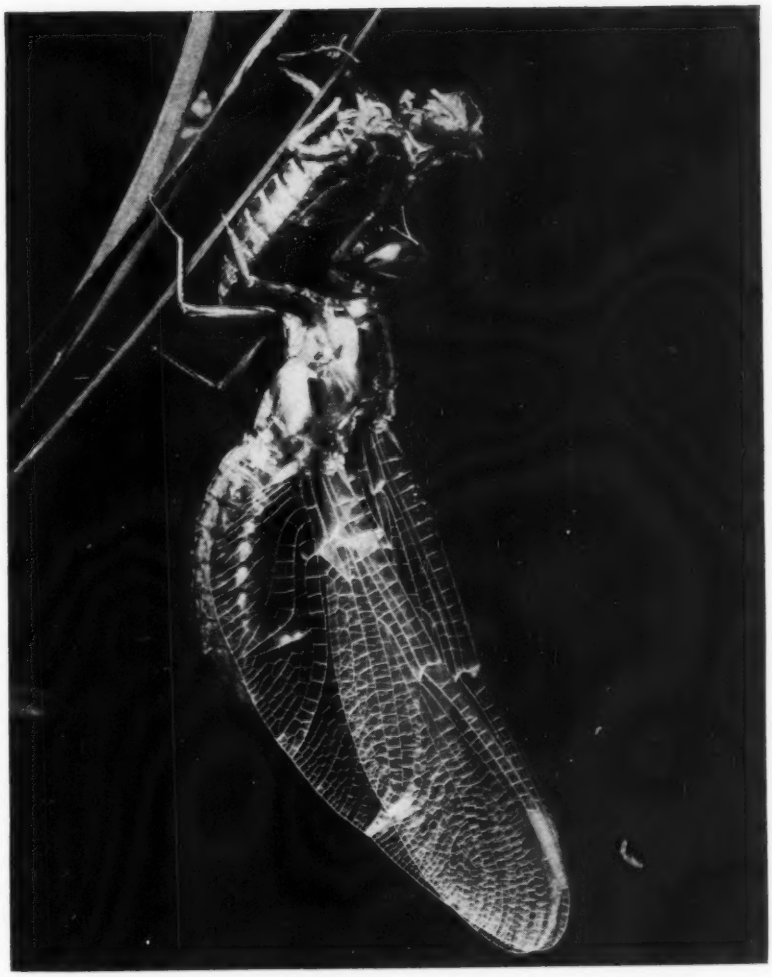
Insects are remarkable little animals. All of us have, at one time or another, watched ants lift relatively great weights; and the questions usually asked were about like these: If an ant were as large as a horse, could it move a house? If tiger beetles were as big as dogs, would they be as dangerous as tigers?

The writer once saw an ant lifting a stone, and both ant and stone were collected and brought back to the laboratory. There, each was weighed on sensitive scales, and it was found that the ant was lifting fifty-two times its own weight! This is perhaps equal to a man's lifting four tons. A few years ago one experimenter placed heavy loads on a beetle's back and found that it could thus lift 850 times its own weight. At this rate a man should be able to lift a small ship.

Insects hunters are powerful, of course, and in their combats with each other they are vicious foes; yet, if they were as large as tigers, they would probably be no match for these beasts. Why? Well, it's all a matter of muscular power. The power of a muscle depends only upon the area of its cross section. The length of a muscle has little to do with its strength or power. In other words, two muscles having the same diameter will both have the same power even though one is an inch long and the other two inches long.

Thus are insect hunters and trappers equipped.

And now just a word about their life stories — insects do not grow up in the same way that other, larger creatures do. A puppy, for example, looks very much like its mother, except that it is smaller. In most cases, young insects do not resemble their parents at all. For instance, the dragonfly lays her eggs in the water, and these hatch into strange, crawling creatures called *nymphs* that live among the vegetation beneath the water of ponds and lakes. Suddenly one day these nymphs climb up out of the water, their skins split open, and out come graceful, winged dragonflies — miracles of transformation!



YOUNG DRAGONFLY lives in ponds. When it matures, it crawls up on a weed, its back splits open, and a graceful insect emerges. *Life size of adult: 2 inches long.*

Other insects such as the wasps have a resting, or pupal, stage between the young and adult stages; so we may say that there are four stages in their lives: egg, larva (young), pupa (resting), and adult (winged).

Still other insects like the praying mantis have only three stages. These are the egg, which then hatches into a young mantis that looks like its mother except for the absence of wings, and finally the full-grown adult. In this case there is no pupal, or resting, stage.

Among the hunting and trapping insects we find all three general types of life histories. Sometimes they become hunters or trappers from the moment that they hatch from the egg, but in other cases they do not enter upon this career until they are fully grown.

Dr. Ross E. Hutchins is head of the Department of Zoology and Entomology at State College, Mississippi, and Entomologist of the Mississippi State Plant Board. He has been photographing insects, animals, birds, and plants for nearly thirty years.

By Eliot Tozer

QU-I-I-I-ET!!!

The muffling of a jet engine's roar, the silencing of factory noise, the soundproofing of the home — these are problems faced by sound engineers

■ It takes very little energy to make noise. In fact, the acoustics experts at Armour Research Foundation in Chicago once made this estimate: if all the people in that huge city were to talk at the same time, the roar could be heard for a mile — but the energy used to produce the roar would barely light a 100-watt lamp. Similarly, jet engine manufacturers say that the scream of a turbojet is produced by less than 1/10 of 1 per cent of the engine's power.

Yet the noise of a jet — or of an air conditioner, a blast furnace, or a diesel truck — is, in a sense, unnecessary. A locomotive cannot pull more freight because it rumbles; a vacuum cleaner is no more efficient for its whine.

And certainly no one likes noise. Some noises, in fact, are costly. Residents of Westport, Connecticut, for example, recently complained that diesel-train noise was destroying the value of their property. Other noises are dangerous. Jet-engine noise on Navy carrier decks, for instance, interferes with communication between plane handlers and sometimes confuses them.

So acoustics — the science of sound — has suddenly become important. Since World War II, a dozen full-time acoustical engineering firms have been established where there were none before.

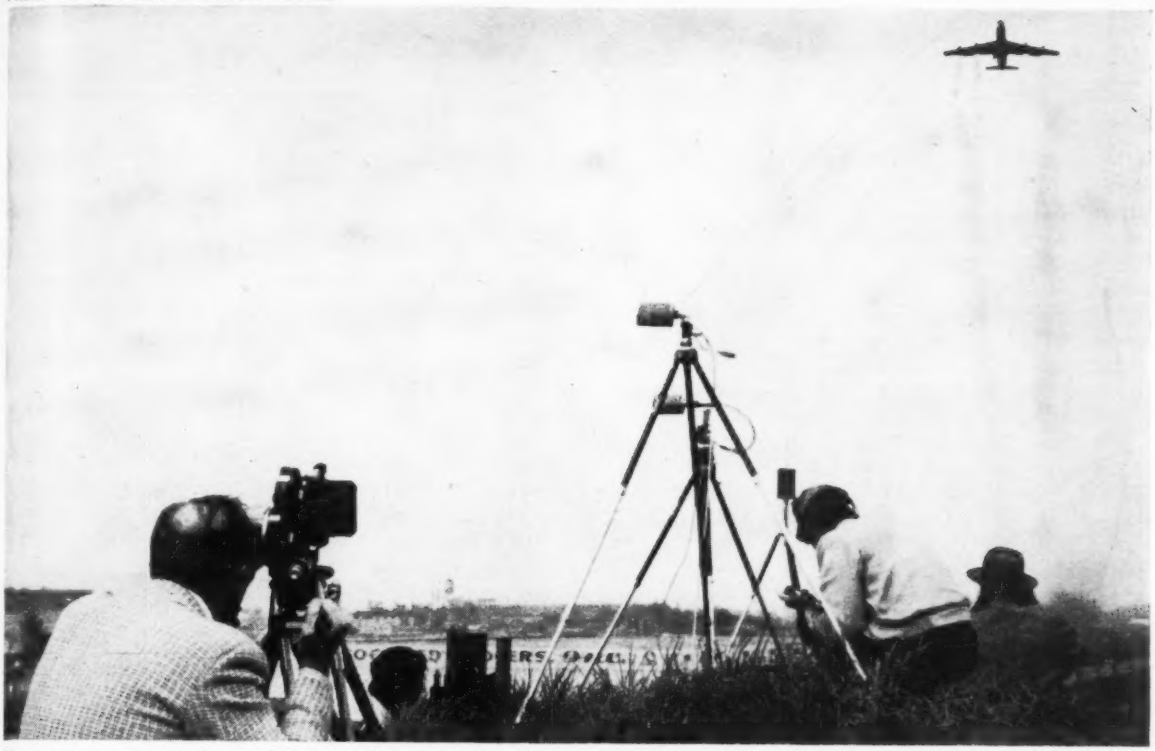
The acousticians have had their troubles, because noise is extremely complex. To understand and control noise, an acoustician must be part physicist, part electrical engineer, part mechanical engineer, part architect — and part psychologist. Psychology is important, because the decision as to whether a given sound is "noise" or "sweet music" is made by people. And people are even more complex than sound itself.

Sound is a physical or mechanical disturbance that can be detected by the human ear. If you strike a tuning fork, it vibrates, setting the surrounding air particles into motion. The particle motion produces fluctuations in the atmospheric pressure (see drawing on page 11). These are called *compressions* (regions of increased pressure) and *rarefactions* (regions of decreased pressure). The fluctuations radiate outward in all directions from the tuning fork in the form of waves. Striking the ear, they are transformed into nerve impulses that travel to the brain.

You may have noticed that a small tuning fork vibrates more rapidly than a large one and that it has a higher pitch. The number of vibrations per second of a tone is called its *frequency*. As the frequency increases, the pitch goes up. Middle C on the piano has a frequency of 264 cycles per second; A above middle C has a frequency of exactly 440 (by international agreement among musicians). Acousticians must learn the frequency characteristics of a noise before they can suppress it.

They must also know the "shape" of the sound waves. This is determined in part by the wave length (the distance between the peaks of the waves). On an oscilloscope, a device that converts sound into a visual pattern, the sound of a

Photos from Bolt Beranek and Newman Inc.



NOISE OF JET ENGINES is especially annoying to people. Here, acoustical engineers gather data on noise of cruising jetliner.

vibrating tuning fork appears as a classic wave form. This is the simplest sound of all. It is called a pure tone (see drawing, page 11) because it is composed of but one frequency.

The wave of a musical tone follows the same basic form, but has irregularities. It is composed of a single tone (the fundamental) plus integral multiples of this frequency (harmonics).

When you make a noise, however, the wave form disappears into a jumbled pattern of highly irregular lines.

The intensity of sound must be studied, too. The range of sound intensities is great. The ratio of the most intense sound you can hear to the faintest is about ten trillion to one.

Sound itself follows the laws of physics. And it is measured according to the laws of mathematics. Thus far, the picture is clear, logical. Now, enter the human being. Immediately, the picture becomes confused.

Item: If you add two sounds of equal intensity, the resultant sound has twice the intensity of one. But it does not sound twice as loud to us.

Item: Two tones of the same intensity but of different frequency do not sound equally loud to us.

In other words, physiological reaction to sound is a complicated event. And it's hard to measure accurately.

Our mental, or psychological, "set" confuses the picture even more. Take, for example, the story about the English country gentleman who called a nearby jet-engine manufacturer to complain that the engines were keeping him awake. The manufacturer moved the engine test cells several miles away. But a few nights later, the gentleman called to say he could still hear those pesky engines — *if he listened very carefully!*

What was so annoying? Probably the inappropriateness of the engine noise. Scientists have found that people react sharply to sounds that seem out of place. For example, the crackling of a popcorn bag in a movie theater. It's not a loud noise, but it's out of place and so makes us squirm — unless we're eating it ourselves.

"The 'information content' of a noise also determines how annoying it will be," says Dr. Jordan Baruch. He is Director of Research at Bolt Beranek and Newman Inc. of Cambridge, Massachusetts, the foremost noise consultants in the country.

Dr. Baruch tells this story: "When my little boy was 2½ years old, he often whimpered and cried if we entertained friends at night. I figured that the words he heard — not the sounds — were keeping him awake. So I turned on the shower, and he went to sleep."

The sound of running water may actually have increased the intensity level of sound, but it blotted out the words — that is, removed enough information content so that the child was no longer disturbed. Other acousticians have quieted fussy children by turning on a vacuum cleaner.

Unexpected sounds — as you

might guess — are more annoying than those you are prepared for. And irregularly intermittent sounds annoy more than regular sounds do.

Not long ago, a resident of Howard Beach near New York City called the Port of New York Authority, which, among other jobs, operates four airports in and near the city. He threatened to shoot down the next jet transport that flew over his home. Had he not been pacified, he might well have "taken down his rifle," as he said he would, and fired at one of Pan American's Boeing 707-121's.

Are jets that much noisier than ordinary aircraft? Bolt Beranek and Newman found that the 707 indeed pulses out many more decibels of intensity than the old Super Constellation. But they also found, in a long series of tests, that there's more to jet noise than that.

As consultants to the Port Authority, BB&N made special studies of psychological reaction to aircraft noise. They worked out a new unit of measure called the "Perceived Noise decibel level." It turned out that jets are not only noisier, but also have a higher PNdb than do piston-engine planes. In short, they are more annoying.

SCIENCE WORLD asked Dr. Leo Beranek, president of BB&N, why jet noise is more annoying. He said, "We found that high frequencies bother people more than low frequencies do. The whine of a jet is heavy with high frequencies. It interferes more with speech and hearing. I'm afraid people will never get used to or accept noise levels as high as those made by today's jetliners."

Sometime soon, perhaps by 1962, Dr. Beranek believes that a quieter jet engine will be produced. Meanwhile, the Port Authority is reducing jetliner PNdb by following the first and simplest rule of sound suppression: put distance between the source and the hearer. The Authority is asking pilots to be at an altitude of at least 1,200 feet when they fly over the first houses. For sound follows the inverse-square law: intensity of wave energy decreases in inverse proportion to the square of the distance from the source. If you move 100 feet from an engine, its sound energy is reduced by a factor of 10,000.

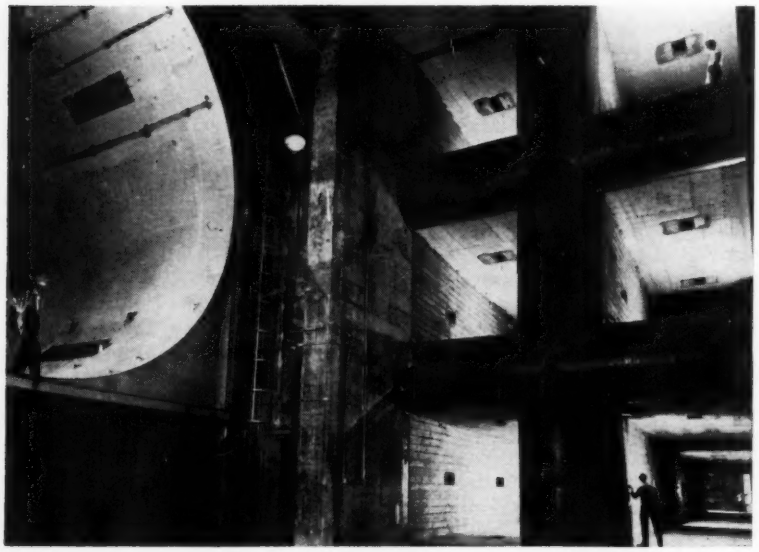
Sometimes, acousticians suppress noise by eliminating it at its source, the second rule. In January, 1950, BB&N got an urgent phone call from the engineers at the Lewis Flight Propulsion Laboratory in Cleveland. The night before, lab engineers had run a test of a ram-jet engine in their $100-million wind tunnel. Homeowners as far as ten miles away had bolted out of bed, crying, "What's that noise?" Some had complained to the police that a "rumbling noise" had rattled the bottles in the medicine cabinet. Others thought there had been an earthquake.

BB&N acousticians took measurements with sound-level meters and knew they had a tremendous silencing problem on their hands. The "rumble" had been caused by 40-cycle tones — that's about the lowest note on the piano — with a wave length of 27 feet. Now, to absorb noise, you must use baffles that are about as thick as one-quarter of the wave length. So BB&N recommended the construction of a mammoth sound absorber 220 feet long, 33 feet wide, and 46 feet high. The absorber would be honeycombed with 10-by-10-foot chambers whose walls would be lined with 6-foot-thick baffles.

But that was only the beginning. The "earthquake" had been caused by sub-audible sound whose wave length was 200 feet. To absorb this, BB&N cut deep, 6-by-2-foot resonators in the walls of the original wind tunnel, each one tuned to a different low frequency. As the sound passed these resonators, certain frequencies were pulled inside. There they vibrated back and forth until they died out.

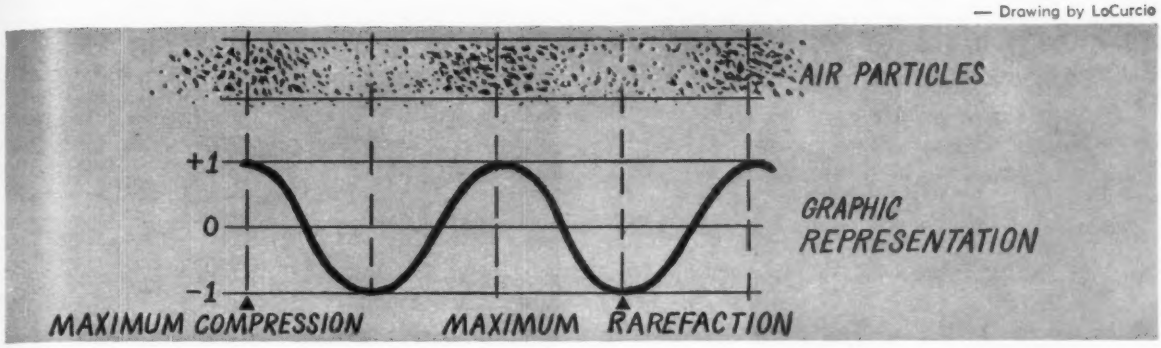
The third rule of sound suppression is this: stop the sound somewhere on its path to the hearer. Dr. Laymon Miller of BB&N once solved a vexing problem for a manufacturer whose offices were as noisy as the factory itself. It seems that the sound of the machines was setting up vibrations in the air that were making the floor beams vibrate. These vibrations were traveling along the beams and coming out, several hundred feet away, as noise. Dr. Miller showed the manufacturer how to "float" his offices in mastic so that there was no rigid connection between them and the factory. In that way, the vibrations — and noise — wouldn't reach his offices.

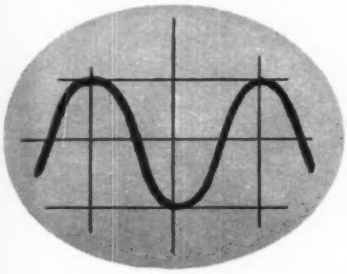
Want to soundproof your own room to keep out the yelps of little brothers and sisters or the din of



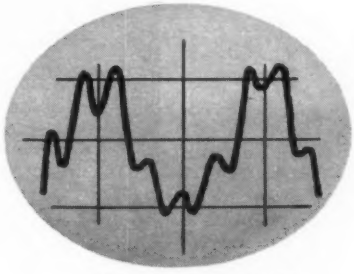
MAMMOTH SOUND ABSORBER, consisting of six passages, was added to wind tunnel at Lewis Flight Propulsion Laboratory to reduce the terrific din of jet-engine tests.

— Drawing by LoCurcio

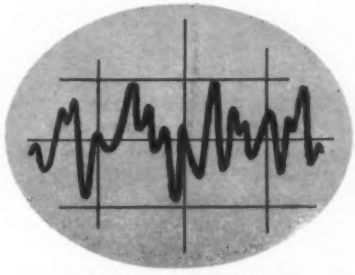




PURE TONE



MUSICAL TONE



RANDOM NOISE

TV? It might be a good idea, but you'll have trouble. It's very hard to suppress sound for the simple reason that sound is so easy to produce.

You might think a cinder-block wall would be fairly soundproof. But sound goes through bare cinder block almost as easily as light goes through glass. If you yell in one room, your vocal cords set the air vibrating. These vibrations set the wall vibrating; and the vibrations come out on the other side as sound. By the same token, you can talk to someone through a heating duct because the lightweight ducting is so easily set in motion.

Sound also goes through a cinder-block wall because the block is porous. Even a concrete wall is easy to talk through if there's a crack in it.

The two basic rules of soundproofing a room, then, are (1) prevent the wall from transmitting sound and (2) seal all leaks. Best way to do this is to build double walls, each a foot thick — of concrete. Then, as an added precaution, make sure they are not rigidly connected.

Next best thing is to build another wall inside the original walls of the room and make certain they are not connected. Then, seal all leaks around doors with urethane rubber gaskets.

Acoustic tile cannot keep sound out; nor can it keep the noise you make from traveling into the next room. Sound goes right through tile. Tile does, however, lower the sound level in your room by absorbing some of the waves that would normally bounce back. The waves burrow into the little holes and dissipate their energy as heat.

Weather plays funny tricks with sound. The shriek of a train seems to travel farther at night, and measurements show that it sometimes does. After dark, the air is often warmer at higher altitudes. This condition causes some of the sound rays that have radiated upward to bend back down to earth, many miles away. Dr. Uno Ingard of the Massachusetts Institute of Technology estimates that the sound of some jet engines could travel more than 100 miles on certain nights.

Fog, rain, and high humidity do not weaken sound waves, although many people think they do. But a gusty wind can damp off high-frequency noise.

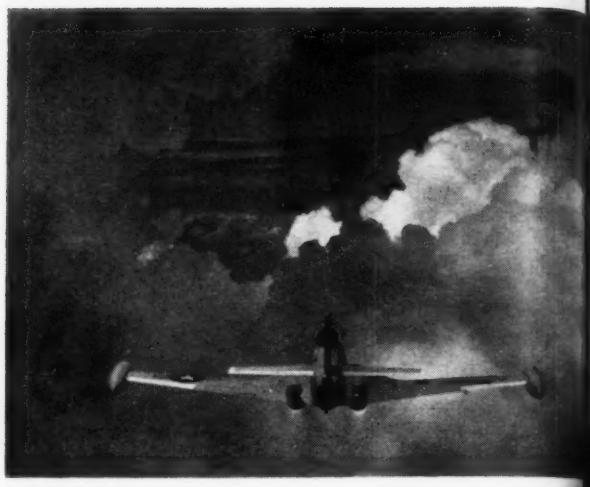
Acousticians foresee a big and bright future for their science. They expect to learn much more about sound, how it travels, and how it can be reduced. In fact, they must. Machinery is getting bigger and noisier each year.

The scientists also want to learn much more about our peculiar psychological reaction to the tiny pulsings of air particles against our ears.

Nor does the work of sound engineers necessarily stop with sound itself. As Dr. Baruch has said, "Our specialty is anything that moves." BB&N engineers are building a particle accelerator that can sling slugs of metal at a speed of six miles per second. Basically, it is a simple electromagnet. Yet from it could come a defense against ballistic missiles.

Other sound engineers hope to help launch our own ICBM's more accurately by studying the mathematics of the eye of the horseshoe crab. It seems that the crab's eye, though inefficiently put together, functions beautifully even when parts of it are cut out. "Just think," says one engineer, "what we could do if we could find the mathematical secret of this eye and apply it to missiles. Then if a missile part burned out, the bird would still fire accurately."

Quiet, please. Scientists thinking!



By Edmund H. Harvey Jr.

Bright forecast for weather

Aided by radiosondes, radar, electronic computers, and other modern devices, meteorologists stride ahead in understanding the weather

■ "Everyone talks about the weather, but nobody does anything about it," quipped Mark Twain some fifty years ago. Since then, things have changed. Today, meteorologists are unveiling, link by link, the long chain of cause and effect behind our weather — behind what makes it windy or stormy or clear and calm in a certain place at a certain hour. With increasing knowledge has come increasing accuracy in weather prediction.

Meteorology requires an immense and continuous flow of observation and measurement. For this reason, the U.S. Weather Bureau maintains close contact with some 10,000 volunteer weather observers around the country, who supply the Weather Bureau with information about their local weather. But the really crucial spots in the U.S. weather-watching network are six hundred Weather Bureau stations scattered around the United States. In addition, the Weather Bureau gets daily reports from foreign weather stations in the Northern Hemisphere.

One day, manned weather stations may be replaced by a global chain of electronically operated weather stations reporting continuously to an immense electronic computer. But that time lies ahead. Right now, the Weather Bureau makes use of electronics in a variety of weather-checking devices. One of these is the radiosonde. Radiosondes contain instruments for making observations of wind, temperature, and air pressure; they also carry a radio transmitter for relaying this data back to a weather station. Radiosondes are sent aloft by balloons, reaching altitudes of up to fifteen miles. At a certain altitude, because of decreased air pressure and lowered temperature, the balloon swells and bursts. The tougher the balloon, of course, the higher it goes before it pops. The radiosonde floats slowly back to earth by parachute, transmitting weather data all the way down.

A close relative of the radiosonde is the dropsonde. Taken aloft by a plane, it is parachuted to earth from the desired altitude.

Radar is used by Weather Bureau stations to track balloons sent up to check the speed and direction of winds in the upper atmosphere. Radar is also used to track storms

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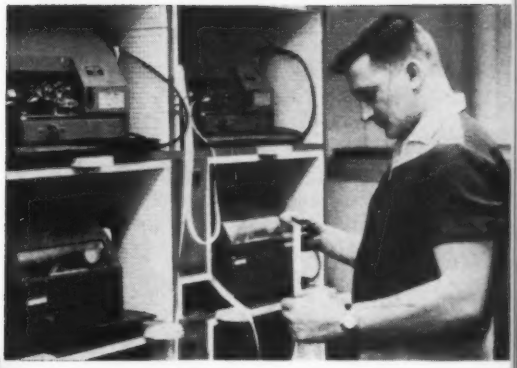
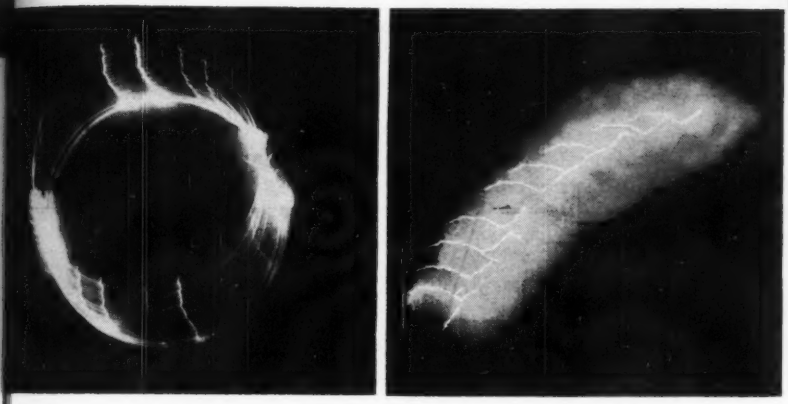
Material in this article is based largely on the Bell System Science Series program, "The Unchained Goddess."

Hurricane-hunting planes photograph storm (*left*), drop balloon into its 'eye.' Cross section of hurricane (*above*) shows balloon moving with storm. Signals sent out by balloon enable scientists to track hurricane's path.



Weather information comes in on tapes (*above*) to the National Weather Analysis Center in Maryland, is fed into a computer, which registers it on a map.

Illustrations from "The Unchained Goddess"



Lightning doesn't always strike as a single jagged line, as these photographs show. It can strike as a series of strokes, as many as forty coming in less than a second.

— especially hurricanes and tornadoes.

Use of rockets and satellites for weather observation is, of course, in the very early stages. Their most obvious advantage will be to get "on top" of cloud formations and photograph them over millions of square miles. Camera-carrying rockets have already brought back highly satisfactory pictures of cloud formations ("Science in the News," *SW*, Feb. 24). But meteorologists need practice before they can "read" such on-top pictures accurately. (It's a little like trying to identify a person by the back of his head, rather than by his face.) Not long ago, for example, a rocket-borne camera caught a curious cloud formation over the Gulf of Mexico. Meteorologists couldn't be immediately sure about the strange cloud cluster, but later investigation showed it to be an embryonic hurricane. The rocket camera had spotted it long before it was picked up by surface radar equipment. Meteorologists are already talking about a television camera that would reveal a destructive storm as soon as it began to form.

What makes weather? Primarily, it's the continuous circulation of air over the earth, which is caused by the heat of the sun. As air is heated, it rises; then cooler air moves in to take its place. In turn, this air is heated, and more cool air moves in — a process that is repeatedly endlessly.

This process explains the world's great prevailing winds. Air around the equator is always subject to great heat; it rises and is replaced by cooler air moving down from the poles. So far, so good. But how do we explain the fact that the three main prevailing winds in the Northern Hemisphere blow east and west instead of north and south? The answer lies in the rotation of the earth.

You can get a rough idea of what happens if you imagine yourself launching a rocket from the North Pole, aimed directly at New York City. While the rocket is in the air, the earth is turning eastward beneath it. For this reason, the rocket would land hundreds of miles *west* of New York. Now, if you read "wind" for "rocket," you have air moving from east to west.

This explanation takes care of the polar easterlies and trade winds, which move generally east to west. But it doesn't quite explain why the prevailing westerlies seem to

loop around and blow *west* to *east*. Scientists are still searching for the exact explanation. In general, however, it's safe to say that the heat of the sun creates the earth's prevailing winds, and the rotation of the earth directs them.

Without air circulation, there would be no clouds, and therefore no rain, no snow, no hail, no thunder and lightning. When warm air rises, it carries with it billions of invisible dust particles. The rising air also carries water vapor, evaporated from the sea. As the air moves higher, it is cooled — and the water vapor is forced out. The tiny water molecules then attach themselves to the dust particles, and together they form visible cloud droplets. Billions of cloud droplets make up a cloud.

When it rains in our latitudes, this usually means that ice has formed around some of the dust particles in overlying clouds. The ice crystals build. When they are heavy enough, they begin falling. On the way down, they encounter warmer air and turn to rain. If they don't encounter warmer air they remain frozen, and it snows. Hail is formed when updrafts sweep falling rain back up into the freezing area of a cloud, where raindrops get repeated coatings of ice.

Everyone who has listened to a weather forecast or seen a weather map has heard of "high" and "low" pressure systems. This simply means that over a certain large area the air pressure, as measured by a barometer, is either higher ("heavier") or lower ("lighter") than in a certain other area. Highs and lows are always moving, always changing. From all over the Northern Hemisphere, reports on air pressure are relayed by teleprinter circuit to the Weather Bureau's Weather Analysis Center at Suitland, Maryland. There, some 200 specialists, aided by an electronic computer, chart the hourly progress of highs and lows.

Once high and low pressure areas have been established, meteorologists can be pretty sure of finding certain other weather conditions. A low pressure system usually means unsettled weather; a high means fair weather. Winds usually tend to blow counterclockwise and inward around a low; clockwise and outward around a high.

Another major part of weather prediction is the location of cold and warm fronts. Fronts are really the boundary lines between warm and cold air masses. When a cold front pushes under a warm front, meteorologists know it will travel about twenty-five miles an hour and bring clouds and precipitation directly ahead of it. However, when a warm front moves over a cold front, it can spread bad weather more than a hundred miles ahead, and it moves much more slowly.

Weather prediction is based on the location of pressure systems and fronts — plus a mass of other data. It rests on the supposition that, given certain factors of weather, certain other factors of weather will follow. Today's forecasts are about 85 per cent accurate. That's a tremendous improvement over even a few years ago. But there still remains that 15-per-cent gap. Will it ever be closed? Scientists can't be sure. Perhaps there are unmeasurable factors, unpredictable effects.

Can man control weather?

That's one reason why scientists are cautious about promising too much for the future of weather control. Most feel that, before man begins to tamper with the weather, he should know *exactly* what will happen, exactly what the consequences of his attempts will be.

A second reason: so far there has not been any really conclusive evidence that man can change the weather. (Neither has there been any conclusive evidence he can't.)

Nonetheless, there's been some free-wheeling speculation about how weather can be controlled. One scheme envisions miles of silver-coated plastic hung from space stations to concentrate the sun's heat on certain parts of the earth. Another, warming up Hudson Bay with atomic furnaces. Another, changing the surface color of the ocean to alter its reflective properties. Another, increasing or decreasing the solar energy reaching the earth by spreading chemicals in the upper atmosphere with rockets.

The one weather-controlling method on which scientists now have any appreciable data is cloud-seeding. To effect this, the cloud droplets or ice crystals in clouds must be built up to a big enough size to fall by their own weight. There has been some indication that, under certain circumstances, both silver iodide crystals and dry ice are more effective than the natural dust particles in collecting water vapor and building up to snowflake size. But because successful cloud-seeding seems to require just the right kind of cloud in just the right place, many scientists see it as a very limited weather-control method.

Whatever the future of weather control, you can be sure that weather will continue to exert control over you — and in ways that an umbrella or snow tires can't combat.

Have you, for example, ever felt sluggish and irritable on a rainy day? You probably had a perfect right to feel that way. When air pressure is low, many people's body tissues take up more water. These swollen, water-logged tissues increase the pressure inside your body, causing aches and pains and sometimes impeding blood circulation. By contrast, high pressure keeps the water out of the tissues; it makes many people feel happier and more energetic.

Heat coupled with high humidity makes it difficult for you to give off body heat, and this can have sizable emotional effects. Some people are emotionally upset by a continuous wind, others by continuous bright sunlight or by prolonged overcast.

All this makes a good case for "spring fever." Pressure variations are greatest in the spring, and weather in the Northern Hemisphere is most unsettled and turbulent. The body continually has to readjust to weather variations; for example, from very high pressure to very low pressure. So if, in the next month or two, you have an attack of spring fever, don't get talked out of it: it really *is* the weather.

The Bell System Science Series program, "The Unchained Goddess," will be telecast over the NBC network Sunday, March 22. Check your local TV listings for the time this program will be seen in your section of the country.

There will be no steaks or French fries aboard the first moon-bound spaceships.

Here's a preview of the menu men may expect

When dinner is served—in space

By Isaac Asimov

PART I ■ If there is one thing that must be cut down on a spaceship, it is unnecessary mass. Therefore, fuel and oxidizer used for rocket power must be as concentrated as possible. They must give the greatest possible thrust per pound.

Furthermore, the fuel and oxidizer leave the ship as they are used. And, for that matter, the empty tanks and compartments that contained them are also discarded.

Can the human crew be powered on that same principle? Can its food, water, and air supply be carried along in the most concentrated possible form and then discarded after use?

The answer is: "Yes" for a short trip, such as that to the moon; but "No" for longer trips.

Since, for the present at least, the trip to the moon is the important task that space scientists have set for themselves, it is the "open system" that will be used on the earliest spaceships. An "open system" is one where the necessary supplies for the crew are discarded after use.

Let's see what is required for such a system and how much of a strain it will put on our efforts to send men to the moon and back.

What must each man have, and how much?

Item 1: he'll need energy. In a spaceship, men won't be moving around much; they won't be running races or shoveling snow. So an individual will be able to get by easily on 3,000 food calories a day. These calories can be supplied by carbohydrate (either as starch or sugar), by protein, or by fat.

It would take about 1.6 pounds (26 ounces) of either carbohydrate or protein to supply the daily energy requirement. Fat is a more concentrated energy food. A mere 0.75 pounds (12 ounces) of fat would do the trick.

To save all possible space, then, it would seem logical to supply each spaceman with 12 ounces of fat a day. However, a diet of pure fat would be horrible. Besides, the body handles carbohydrate most easily.

A mixture of fat and carbohydrate would be best. The carbohydrate might be in the form of lactose (milk sugar) or dextrins (partially digested starch). These are easily digested and not sweet to the taste. (An entirely sweet diet would become quite unbearable.) As for the fat, that might be in the form of a bland vegetable oil.

Imagine a rather gooey mixture

of carbohydrate and fat in little cartons made out of slivers of solid, but edible, carbohydrate. Each carton might weigh about 6 ounces, and there would be one per meal. Suck or squeeze out the semi-liquid contents, then eat the box. Three a day, and, as far as energy is concerned, the spaceman's needs are met.

Naturally, flavors would be added for the sake of variety. Some of the cartons might have a cheesy taste, some meaty, some fruity, and so on. Not ideal, but astronauts can't expect service à la Ritz.

Does this mean the spaceman is all set? Not quite.

Item 2: he'll need tissue-builders and certain essential chemicals. I have omitted protein as an energy source, because carbohydrate supplies energy more directly and fat supplies it in more concentrated form. However, protein offers something neither of the other food classes does. It provides nitrogen (also some sulfur), which is absolutely required for tissue-building and replacement.

A minimum of 2¼ ounces of protein will supply the daily requirement of nitrogen. But not any old protein will do the trick. The body digests protein by breaking its large molecules into smaller molecules called amino acids. These amino acids are absorbed into the body and built back up into tissue protein plus other necessary compounds. There are some twenty different amino acids. Of these, the body can make all but eight out of simpler substances.

The eight amino acids the body cannot make must be present in the diet in certain minimum quantities. An ample daily ration is 1/25 of an ounce of each. If that much of each is present, the remaining two ounces of protein can be the cheapest available — gelatin, for instance.

The body needs other substances in the diet in still smaller quantities. Some of these are organic compounds which, like the eight amino acids just mentioned, the body cannot make for itself. For example, one is a compound called linoleic acid. This is present in most fats and would probably be included in the vegetable oil already mentioned as part of the spaceman's ration. If not, a bit of it would have to be added.

Other necessary organics are the various vitamins. Ascorbic acid (vitamin C) is needed to the extent of about 1/350 of an ounce per day. Other vitamins are required in even smaller proportions. For instance, 1/20,000 of an ounce of thiamine (vitamin B_1) per day is essential, as is 1/30,000,000 of an ounce of cyanocobalamin (vitamin B_{12}).

Then there are minerals. The body requires about 1/30 of an ounce of calcium each day and an equal quantity of phosphorus. Somewhat larger quantities of sodium, potassium, and chlorine are needed, and somewhat smaller quantities of magnesium and iron. Copper, cobalt, iodine, fluorine, zinc, molybdenum, and manganese are necessary in very small quantities. The total mineral needs might come to about 1/3 of an ounce a day. A good part of this requirement could be met with salt.

All of these substances — proteins, vitamins, and minerals — could be added to the astronaut's basic ration without adding much to its bulk. The fortified ration would come to 7 ounces a meal, or about 20 ounces a day.

One way of preparing the ration would be to begin with a lightly salted basic mixture of dextrin, corn oil, and gelatin. Measured quantities of necessary amino acids, vitamins, minerals, and flavoring could be added. Another way — and perhaps a simpler one — would be to make the ration from, say, dried whole milk. This would contain almost all the necessary items required by man, and in the proper proportion. The chief deficiencies that would have to be made up would be iron, copper, and vitamin C, with a little vitamin D added for good luck. (It is doubtful that male adults really need vitamin D, though children do.)

Is the astronaut all set *now*? Well, no.

Item 3: he'll need water. Man needs about 1/30 of an ounce of water for every calorie of food. This amounts to somewhere between 2½ and 3 quarts a day. (That may surprise you, since you certainly don't drink that much water each day. But you do take in a lot of water in the form of other fluids — milk, soda pop, and fruit juice, for instance. And what is generally considered "dry food" also contains considerable water.)

Some of the necessary water might be added to the astronaut's food ration to thin it out and to make it easier to suck out of the container through a nipple. (There's no gravity on a spaceship, remember. So the stuff couldn't be *poured* out.) The remaining water could be taken straight, perhaps out of another edible and insoluble container like the first.

The result is that each person on a spaceship would need 20 ounces of food and 90 ounces of water per day.

Now is he ready? I'm afraid not.

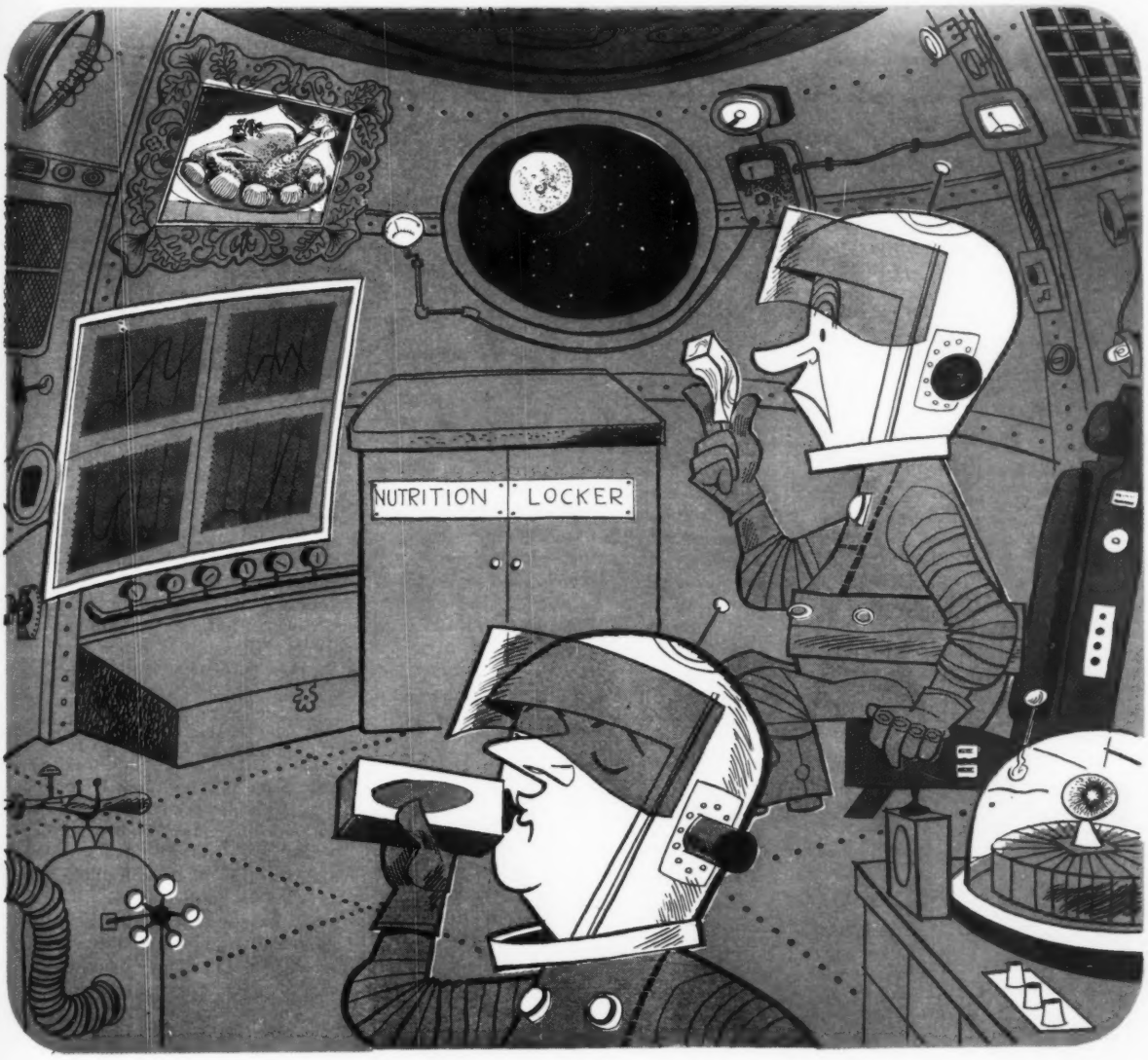
Item 4: he'll need oxygen. To make energy available to the body, food must be combined with oxygen. And man must get the necessary supply by breathing gaseous oxygen.

About 40 ounces of oxygen are required for each 20 ounces of a food supply that is a reasonable mixture of carbohydrate and fat. The most compact way of storing the oxygen would be in cylinders of liquid oxygen that could be bled slowly into the ship's air supply. In this form, a quart of liquid oxygen would represent a day's supply for one person.

And there you are. Now the spacemen are set. The daily requirement of each person on a spaceship would be: 20 ounces of dry food, 90 ounces of water, and 40 ounces of oxygen. Total: 150 ounces or, roughly, 9½ pounds.

Where does that leave man as far as actual space flights are concerned? Consider a trip to the moon, taking one week each way and allowing two days on the moon's surface for exploration. Each man on the ship would require, in that interval, about 150 pounds of food, water, and oxygen. This could be carried.

But suppose we were to send an expedition to Mars and back? That would not take much more rocket



Illustrated by Paul Granger

power than a trip to the moon. Once the escape velocity from the earth was exceeded, it would be largely a matter of coasting the extra distance. During this coasting interval, the ship would consume little fuel, but the crew would continue to eat, drink, and breathe.

What with the trip each way and the wait on Mars for an appropriate astronomical time to return, the entire expedition would be absent about 2½ years. Some water *might* be picked up on Mars, but certainly no food or oxygen. Consequently, for each man on such a trip we would have to send about 5 *tons* of food, water, and oxygen.

There is another problem. All the time a man is consuming food, water, and oxygen, he is manufacturing wastes. Some are in the form of gaseous carbon dioxide, which contaminates the air. Others are liquid and solid. For reasons of comfort and hygiene these would somehow have to be disposed of. On short trips, the small amount of these wastes could be handled. Carbon dioxide could be absorbed by chemicals and the rest could be dumped. But on long trips, not only would each man require tons of supplies, he would produce tons of wastes.

Does this mean that any space voyage to a point more distant than the moon is impractical? Well, no.

There is a way out, and one example of this is in constant operation around us. For the earth is a spaceship. It moves through space with a fixed supply of air and a fixed supply of food and water. Billions of human beings and uncounted other organisms are constantly consuming these supplies and excreting wastes. Yet we do not run out of food, water, and oxygen; nor are we buried under accumulated wastes. The earth is a "closed system." Food, water, and air are not discarded after use, but are endlessly re-used.

How is this done? And how can it be imitated on a spaceship?

[*Conclusion, March 24* SW.]

Science in the news

First weather satellite launched into orbit

A new era of weather research began when the United States orbited Vanguard II. This was the first of at least four weather satellites to be launched this year. The orbiting weather stations are expected to provide man with a more basic understanding of how weather is formed and to lead to more accurate long-range forecasting.

Vanguard II, a basketball-sized sphere, was launched by the Navy's 72-foot Vanguard rocket. Its job: to investigate cloud patterns covering the sunlit portions of the earth. According to early indications, the satellite was doing its job well. Two photoelectric cells inside the vehicle scanned the cloud cover. Information from the photo cells was recorded on tape inside the satellite and transmitted on command to ground receiving stations.

Vanguard II was expected to send cloud-cover data back to earth for a two-week period -- the lifetime of its mercury batteries. The purpose of man's first weather station in space was to show how weather data could be gathered, rather than to gather it. Nevertheless, the Vanguard was expected to spot any typhoons or hurricanes brewing over ocean areas.

Another Vanguard weather satellite to be launched this year will probe the earth's "heat budget" – the amount of energy the earth receives from the sun and the amount it radiates back into space. Devices mounted on the ends of antennae will measure the radiation. Meteorologists hope the experiment will shed light on an old and puzzling question: how the earth's enormous "heat engine," which is powered by the sun, circulates the earth's atmosphere in complex weather-forming patterns. A second "heat engine" experiment will be attempted by the Army.

The most ambitious weather satellite is scheduled to be launched late this year. It will carry one or more miniature television cameras. These will observe the earth's cloud cover over a 1,200-mile-wide path. Images will be taped and transmitted to TV receivers and recording devices on earth. The satellite also may carry infrared devices to explore cloud patterns at night.

— U. S. Air Force photo

Now you see it, now you don't! Master Sergeant Earl Sayre watches glass of water boil away at simulated altitude of 90,000 feet. Experiment took place in test chamber at Wright-Patterson Field, Ohio. Minutes earlier, pressure had been equal to that at 40,000 feet. Physicians said abrupt pressure change would have boiled sergeant's blood if he hadn't been wearing pressure suit.

Chromosome X is three times larger than Y

Why do women live longer than men? The answer may lie in a recent discovery about chromosomes.

Chromosomes are the stringlike bodies in the cell that control traits inherited by offspring. A combination of two of these chromosomes, called X and Y, determines the sex of an individual. In each body cell of a female there are two X chromosomes. In each body cell of a male there are one X chromosome and one Y chromosome. The X and Y chromosomes control other traits in addition to sex.

Now scientists have found that the X chromosome is three times larger than the Y. This means that women have a greater chromosome volume than men. The discovery could lead to answering many questions about the differing reactions of men and women.

Scientists also uncovered another new fact about chromosomes: there may be only 46 of them in the human body cell rather than 48, as previously believed. Exact chromosome counts in 74 persons showed that 95 per cent of all cells examined had 46 chromosomes each.

Sound waves may set oil wells flowing

Oil wells may soon be forced to flow by the use of sound waves. Powerful sound vibrations set up a resonance that can actually fracture oil-bearing rock, just as an opera singer may shatter a glass with his voice. Here's how the new experimental method works:

An electrically operated vibrator is lowered into a newly drilled well that has been filled with crude oil containing sand. Hanging below the vibrator is an 80-foot-long elastic-steel rod. When the rod is vibrated, sound waves radiate from it through the crude oil at a rate of about 100 per second. The sound waves subject the surrounding oil-bearing rock to such stresses that it gives way. Oil flows.

'Youth hormone' now found in humans

For years, scientists have known that a "juvenile hormone" exists in some insects. It can be used to postpone their development, keeping them "young," so to speak. The hormone was later found in rats, sheep, and cattle. Now it has been discovered in man.

Experiments with moths have shown that two glands in the insect's brain secrete the hormone during its larval, or caterpillar, stage. When the caterpillar reaches maturity, no more hormone is secreted. The caterpillar then undergoes metamorphosis, developing into a pupa and finally into an adult moth. But if the juvenile hormone is injected into a full-grown caterpillar, metamorphosis is postponed. The caterpillar grows larger before changing into a pupa.

Recently, Professor Carroll M. Williams, Harvard University biologist, found the juvenile hormone in human tissues. It appeared to be most highly concentrated in the thymus gland. This gland is large and active during youth, but shrivels and may disappear with age. Professor Williams and his co-workers injected an extract of the human hormone into the pupal stage of a moth. The pupa developed into a second pupal stage before it changed into an adult moth.

Scientists have yet to determine exactly what role the juvenile hormone plays in the development of animals and man.

'Smaller and better' is new science slogan

In this age there is great emphasis on making things bigger and better. Rocket engines, for instance. But science is striving just as hard to make some things smaller and better. The new trend requires a jawbreaker to describe it: micro-miniature modularization. Or you might simply call it the science of smallness.

In their efforts to reduce size and weight of equipment, scientists are covering many fields. For example, they're trying to develop a TV set thin enough to hang on the wall like a picture. And they're working on ways to reduce their smallest equipment by as much as 100 times to make it suitable for space craft. Progress in this field has contributed to the success of U.S. satellites (see weather-satellite story on facing page).

One of the biggest reduction problems facing scientists is the complex tangle of wires that make up the circuits of electrical equipment. Now one firm is planning to strip down component parts of their circuits and turn them into thin wafers of glass or ceramics. These wafers would be connected by a dozen or so wires and stacked up to form a module. A module is a tiny electronic unit with all the parts necessary to enable many such units to be connected together. Scientists are looking toward the day when electric circuits, as we know them, will no longer exist. Instead, there will be basic electronic "building blocks" that can be assembled in various combinations according to the particular need.

Air, 800 years old, preserved in ice

Scientists are busily extracting secrets from a giant ice core that contains samples of air more than 800 years old. The ice core is four inches in diameter and more than 1,300 feet long. To get the core, Army researchers drilled deep into the Greenland icecap.

Arctic icecaps are valuable storehouses of data. New deep-drilling techniques now make it possible for scientists to reach back into the past for information never before obtainable. Every snowfall and all the material that fell with it are separately and safely "filed" in the ice for future reference, since they were buried under later snowfalls. Volcanic ash, meteorites, spores, and bacteria that fell at the time of or with the snow are expected to be perfectly intact. Samples of air trapped in the ice are preserved as air bubbles. When the bubbles are analyzed, the content and composition of the air for any given year can be determined. Year-by-year accumulations of snowfall are identified by "rings" that are similar to those in a tree. Each ring was formed by the re-freezing of summer melt-water.

The ice core will enable scientists to determine how much snow has fallen in the area each year since around A.D. 1100. That is when the oldest part of the core is thought to have been formed. One of the Army research group's goals is to determine how much air contamination — if any — has resulted since the industrial revolution. To do this, they'll analyze snows down to layers that fell in pre-industrial times.

After drilling, the scientists shipped sections of the core to the United States for study. An electronic computer is being used to speed up the complex job of assessing the frozen secrets. The Army researchers plan to co-operate in a similar drilling operation in the antarctic. They expect new and improved techniques to result in valuable information about movements of air masses.

News in brief

● An African bird has caught the eye of scientists studying man's age-old problem of baldness. The bird, a male wattled starling, loses feathers on its head in much the same way that man loses his hair. The bird is plagued with "pattern baldness," a V-shaped thinning common to man. Doctors are importing flocks of the birds for controlled laboratory experiments. They hope to find a cure for the bird that will eventually lead to a cure for man.

● Flying through a hailstorm is hard on any aircraft, but especially on a jet. Reason: the plane's great speed increases the impact of the hail. Recently, a jet B-52 bomber ran into a storm of icy pellets after taking off from its base in Texas. The plane managed to land safely, but not before its plastic radar nose was torn away, its windshield smashed, parts of its electrical system damaged, and the leading edges of its wings hammered flat.

● The nation's first post office run by automation will be built at Providence, Rhode Island. Mail will be handled entirely by machines, with help from humans. One device will cull letters from larger pieces of mail. Another will face them in position for rapid canceling. People at keyboards will operate machinery that will sort the mail and send it to its proper destination. The post office will be built by Intelex Systems, Inc., a subsidiary of International Telephone and Telegraph Corporation, at an estimated cost of $20 million. It will be leased to the U.S. Post Office Department for 20 years at an annual rent of $1,400,000.

● A tiny TV camera that can be swallowed has been developed. It will televise the internal organs of a patient. The pictures, magnified 30 to 40 times, will be flashed on a screen. They will allow doctors to study parts of the body in action. The one-pound camera is expected to play an important part in the fight against cancer and other diseases. It will also reduce the need for X rays, lessening the dangers of X-ray damage.

● When night falls in the West Indies, one fish "weaves" and wears its own transparent nightgown. The coral-reef inhabitant, a parrot fish, secrets from its mouth a mucous envelope that folds back over its body. The only openings are two tiny holes at the front and rear of the fish. The action, says one scientist, is governed by a nervous reaction triggered by oncoming darkness.

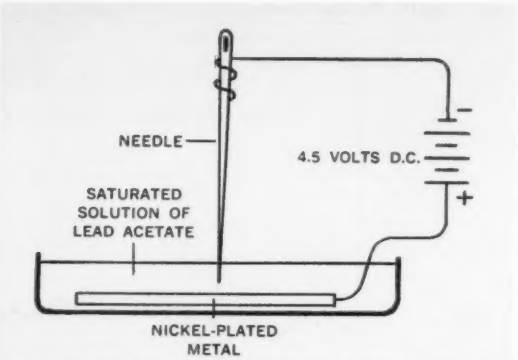


Fig. 1. Apparatus for demonstrating Nobili's rings.

— Illustrated by LoCurcio

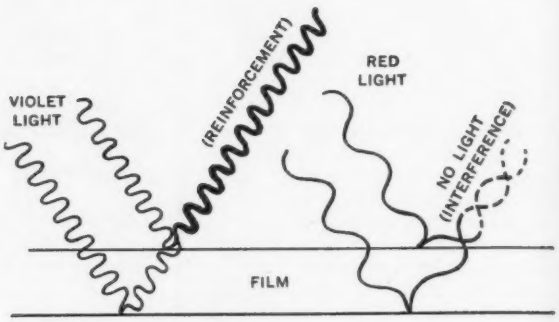


Fig. 2. The interference of light explains the appearance of colors on thin oil or soap films viewed in white light. For the particular thickness shown, red light is removed from the incident white light.

Young scientists

From Nobili's rings to peacock feathers

■ Sometimes discoveries are made or processes invented that flourish for awhile and then drop out of sight — only to be revived decades later when technology is better able to make use of them. A classic example of this is the discovery of the equivalence of matter and energy first announced by Albert Einstein in 1905. From purely theoretical considerations, Einstein developed his famous formula $E=mc^2$ — energy equals mass times the square of the velocity of light. Scientists debated the meaning of this formula. Some said it had no physical significance. Energy and matter were, as far as they were concerned, separate and distinct things. Furthermore, they could not see what the velocity of light had to do with the whole thing. Einstein himself was unable to give a clear-cut explanation of just how matter could be changed to energy, but he did say that if somehow or somewhere matter could be completely destroyed or annihilated, huge quantities of energy would take its place.

Years later, scientists succeeded in doing exactly what Einstein had predicted. And from this they developed nuclear energy.

If we dig through the literature, we sometimes come upon "lost" gems, and while they may not have the impact of an H-bomb, they can certainly give us wonderful leads for projects, which can in turn open up a whole world of exploration.

Nobili's rings

Take, for instance, an unusual and beautiful example of the interference of light, known as Nobili's rings or metallochromes. This phenomenon was discovered by Nobili in 1826 and for a while was used to decorate metallic toys, bells, and watch dials. But, if you ask a modern-day scientist about Nobili's rings, chances are he couldn't tell you what they were.

You, however, can readily experiment with this fascinating phenomenon. And if you do, you are certain to be swept into a study of electroplating, interference of light, diffraction, dispersion, and a host of other subjects.

To demonstrate Nobili's rings you need only a minimum of equipment.

Make up a saturated solution of lead acetate, sometimes called sugar of lead. You will need about 50 grams of the lead acetate to saturate 100 cc. of water. Stir the solution well, allowing the excess solid material to settle to the bottom. Pour the liquid into a shallow container such as a Petri dish. Place a piece of polished, nickel-plated metal in the bottom of the dish. Above, and very close to the plate, clamp a pointed needle as shown in Fig. 1.

Connect the needle to the *negative* of a D.C. supply of about 4.5 volts (3 flashlight cells wired in series will do). Connect the metal plate through a

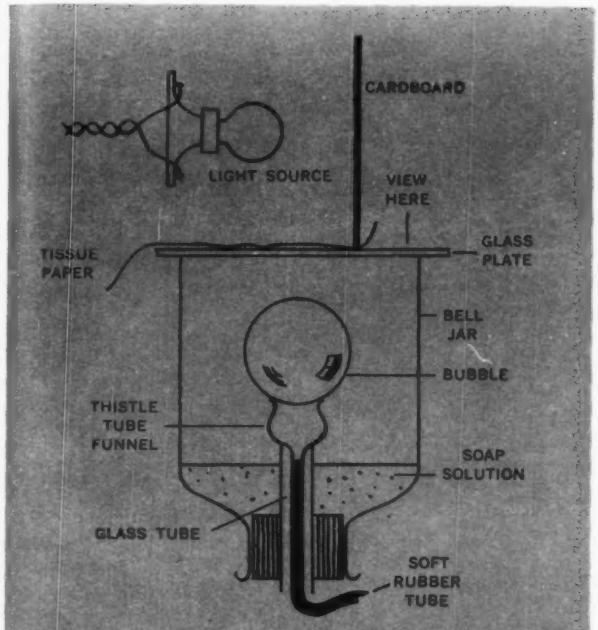


Fig. 3. A device with which you can leisurely watch interference rings appear on a soap bubble. Watch for the black area just before the bubble breaks.

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switch to the positive terminal of the battery. As soon as the circuit is closed, a deposit of lead peroxide begins to form on the plate, molecule by molecule. This develops — in a few seconds — into rings of beautiful iridescent colors. Do not let the reaction continue too long, for the effect depends on the deposition of only a few layers of molecules.

When a pleasing pattern has appeared on the metal, open the switch and remove the plate. Wash the plate in clear water and allow it to dry. During the reaction, metallic lead is deposited on the needle; care should be taken to prevent any of the lead from falling on the plate, because a white spot will result.

The film of lead peroxide, which is deposited on the plate, is thickest in the middle of the rings immediately below the negative electrode. It thins out gradually from the center. In the white light in which the plate is viewed, each particular thickness of the lead oxide causes a particular color to interfere and be canceled out. The light reflected is white light minus the color which interfered. The resulting color is a combination of what is left. Thus, as you view successively thinner layers of the reflecting surface, the color changes gradually, and the effect is that of iridescence.

Many beautiful figures can be produced by using negative electrodes of copper wire bent into different shapes such as a star, a cross, or an initial.

What causes colors?

The origin of the colors exhibited by Nobili's rings is a fascinating study in itself. When a thin film of oxide is formed on a metallic surface, the color of the film is due to interference of light reflected from its upper and lower surfaces. The color will vary with the thickness of the film.

To understand how these colors are formed you must remember that each color of light possesses a different wave length. Red light has the longest wave length and violet the shortest; and orange, yellow, green, and blue fall in between the red and the violet.

Now look at Fig. 2. As a narrow beam of violet light strikes the thin film, some of it is reflected from the upper surface, while some penetrates the film, reflects from the lower surface, and joins the ray reflected from the upper surface. If, when the two rays join, they are "in step," they reinforce each other; the violet light is reflected from the surface.

Let's see what happens to red light with this particular thickness of film. Here the rays from the upper and lower surfaces meet "out of step." They cancel out, and no red light is reflected. Thus, if white light (which, as you know, contains all colors) strikes this film, all colors with the exception of red will be more or less reflected. The result is that the film will appear blueish-green.

Obviously, if the film is slightly thicker (or thinner) the violet light may "interfere" and the red light reinforce; then the film would appear to be reddish in color. In fact, we can estimate the thickness of a thin film by its color. In a wedge-shaped film such as we obtained in our experiment, the interference of red waves takes place in one ring around the center; and the interference of the yellow waves takes place at a different ring.

[*Continued on p. 23*]

On the light side

Brain teasers

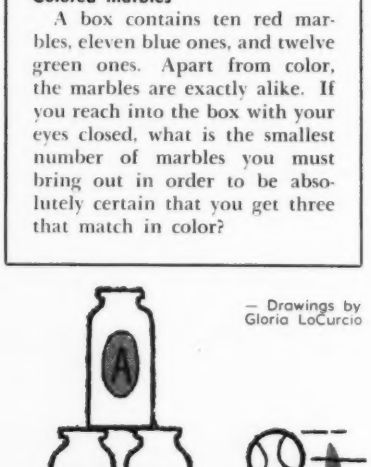
Metal doughnut

If you heated a solid metal doughnut, the metal would expand uniformly. But what would happen to the hole? Would it get larger or smaller?

Colored marbles

A box contains ten red marbles, eleven blue ones, and twelve green ones. Apart from color, the marbles are exactly alike. If you reach into the box with your eyes closed, what is the smallest number of marbles you must bring out in order to be absolutely certain that you get three that match in color?

— Drawings by Gloria LaCurcio



Hurry, hurry, hurry!

Very few carnivals fail to have the milk bottle game somewhere on the lot. Six wooden bottles are pyramided, as shown. The player has three throws with a baseball. If he knocks all six bottles down, he wins a doll.

When the man running the game tosses a ball to demonstrate, the bottles all fall over. But when you try it, though you may succeed in hitting the bottles, there will usually be a bottle still standing after your third pitch.

Can this game be rigged? It can, and the scientific basis of it is absurdly simple. Bottles *A*, *B*, and *C* are much heavier than bottles *D*, *E*, and *F*. For demonstration purposes, the light bottles are placed on the bottom, where they are easily knocked over by the momentum of the falling heavy bottles. When you play, the heavy bottles are placed on the bottom!

The floating balloon

A gas-filled toy balloon of the type sold at fairs and on street corners can be made to hang suspended in the middle of a room, with no visible means of support. Here's how:

Tie a small piece of cardboard to the end of the balloon's string, as shown. Use a piece just heavy enough to keep the balloon from rising. With a pair of scissors, start snipping off tiny pieces of cardboard. In this way you can adjust the balloon's weight until it hangs magically in mid-air.

The trick would not work if it were not for the fact that cool air is heavier and denser than warm air and therefore has greater buoyancy. The balloon hangs at a point where it is too light to sink into the denser air, which stays in the lower part of the room, too heavy to rise into the warmer air above.

The three cards

The odds of winning in certain games are often quite different from what you would expect. Suppose you have three cards: one is black on both sides, one is white on both sides, and one is black on one side and white on the other. You shake them in a hat, then take out a card and place it on the table. What are the odds that the underside will match the upper?

If the top of the card is black, you might reason as follows: "This can't be the WW card. Since it is just as likely to be the BB as the BW, the odds that the underside is black must be even."

As a matter of fact, the odds are two to one! There are *three*, not two equally possible cases: (1) the visible black side is on the BW card; (2) it is one side of the BB; (3) it is the *other* side of the BB. In two of these cases the underside matches the upper, as against only one in which it doesn't.

— George Groth

Answers

METAL DOUGHNUT: The hole would get larger. The doughnut would keep its proportions as it expanded, like a geometrical figure enlarged with a magnifying glass. The same principle is at work when you loosen a tightly fastened metal top of a screw-top jar by running hot water over it. When the metal top expands, its inside circumference also expands, making it easier to unscrew.

COLORED MARBLES: Seven marbles.

Nobili's rings (*Cont. from p.* 21)

When there is interference of red waves, the complementary color (a sort of blue-green) is left; and when there is interference of yellow waves, the color complementary to yellow (blue) is produced.

Steelworkers know that the hardness of steel in the tempering process can be estimated by the play of colors appearing on the metal when it is heated. This is due to the formation of thin layers of iron oxides. For example, yellowish tints indicate very hard but brittle steel, while blue tints indicate the opposite characteristics. Thus, the thickness of the film is indicated by its color, and this in turn shows the temperature to which the steel has been heated.

Soap-bubble colors

The colors of a soap bubble are due to this very same phenomenon of interference. Fig. 3 shows an apparatus that will enable you to blow a soap bubble in a closed vessel containing air free from dust and saturated with water vapor so that the bubble will last for a long time. As the bubble drains, it will show interference rings.

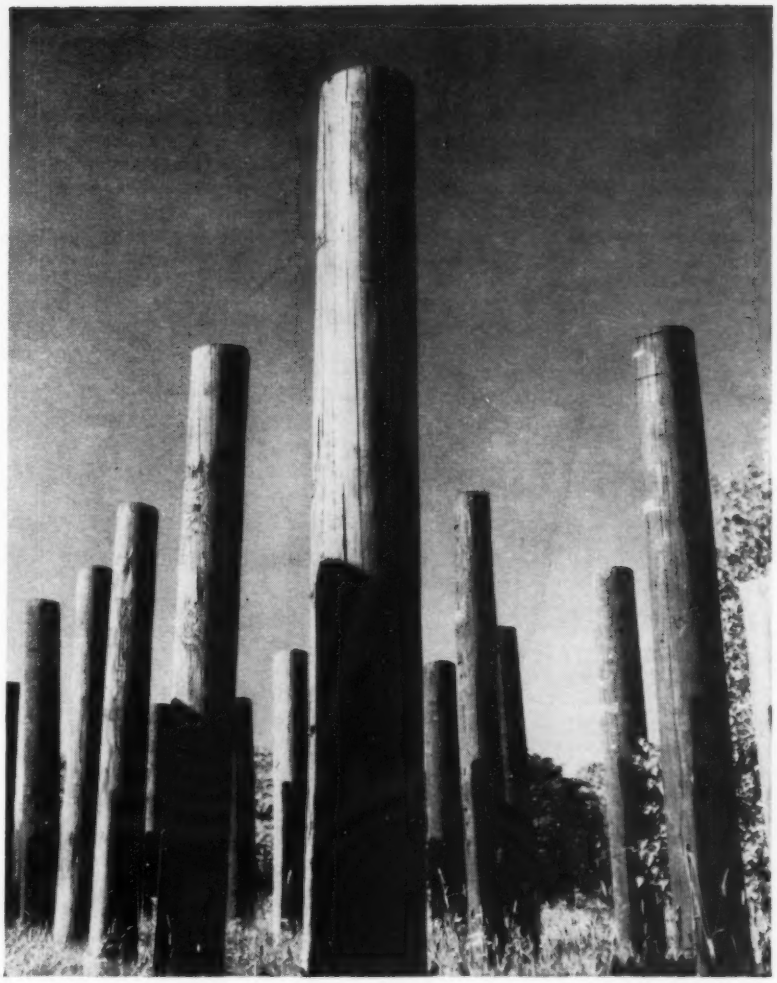
A wide glass tube passes through a stopper in the neck of an inverted bell jar. Inside the glass tube is a narrow piece of rubber tubing attached to a thistle tube with its stem cut short. The soap solution is poured into the bell jar to the level shown, and the top of the jar is covered with a glass plate. Illumination is provided by a bulb above the glass plate, and the light is diffused through a piece of tissue paper resting on the plate.

When the rubber tube is pushed upward from below, the thistle tube funnel flops over of its own weight and plunges head first into the soap solution. When the rubber tube is pulled back, the funnel returns to its original position — but it has a soap film over its mouth. The bubble is then blown (via the rubber tube), and a pinch clamp closed to hold it.

The bubble may last for more than an hour, during which time you can observe the color changes as the film becomes thinner. Just before the bubble breaks, you will note a large black circular area at the top. At that spot the film is so thin that practically all the light interferes and none reflects.

Many beautiful color effects are caused by the interference of light waves in very thin films. The colors of oil films on the surface of water, of the thin films of oxides on metals and on Venetian glass, of changeable silk, and even of peacock feathers, are due to the interferences of light waves.

— THEODORE BENJAMIN



DEATH OF A TELEPHONE POLE

A telephone pole takes a lot of punishment in its lifetime—from driving rains, sizzling heat, blizzards, smashing winds and, especially, decay. It has to be plenty rugged to survive this wear and tear, year after year.

What kinds of wood make the best poles? And what can we do to make them even stronger and tougher? We find out at the Bell Telephone System's research center at Chester, New Jersey. Here all of the equipment that we use outdoors is tested thoroughly.

Pictured above is the corner reserved for testing telephone poles. They are of many different kinds of wood, and treated with different chemicals. Bell System engineers study them closely, seeking the effects of wind, water, ice, heat, insects—even decay caused by certain mushroom-like plants which eat away at poles buried in the earth.

For the poles it's a "life or death" experiment. The tests will tell us which types of poles are tough enough to meet our standards. Some survive; many do not.

Only the most rugged and durable equipment is wanted for use in the Bell System. The result? Better, more economical telephone service for you, your family and your community.

BELL TELEPHONE SYSTEM

Science fiction

Venture to the moon

Robin Hood, F.R.S.

American, British, and Russian expeditions had landed on the moon. Here the British leader recounts certain experiences

By Arthur C. Clarke

■ We had landed early in the dawn of the long lunar day, and the slanting shadows lay all around us, extending for miles across the plain. They would slowly shorten as the sun rose higher in the sky, until at noon they would almost vanish — but noon was still five days away, as we measured time on Earth, and nightfall was seven days later still. We had almost two weeks of daylight ahead of us before the sun set and the bluely gleaming Earth became the mistress of the sky.

There was little time for exploration during those first hectic days. We had to unload the ships, grow accustomed to the alien conditions surrounding us, learn to handle our electrically powered tractors and scooters, and erect the igloos that would serve as homes, offices, and labs until the time came to leave. At a pinch, we could live in the spaceships, but it would be excessively uncomfortable and cramped. The igloos were not exactly commodious, but they were luxury after five days in space. Made of tough, flexible plastic, they were blown up like balloons, and their interiors were then partitioned into separate rooms. Air locks allowed access to the outer world, and a good deal of plumbing linked to the ships' air-purification plants kept the atmosphere breathable. Needless to say, the American igloo was the biggest one, and had come complete with everything, *including* the kitchen sink — not to mention a washing machine, which we and the Russians were always borrowing.

It was late in the "afternoon" — about ten days after we had landed — before we were properly organized and could think about serious scientific work. The first parties made nervous little forays out into the wilderness around the base, familiarizing themselves with the territory. Of course, we already possessed minutely detailed maps and photographs of the region in which we had landed, but it was surprising how misleading they could sometimes be. What had been marked as a small hill on a chart often looked like a mountain to a man toiling along in a space suit, and apparently smooth plains were often covered knee-deep with dust, which made progress extremely slow and tedious.

These were minor difficulties, however, and the low gravity — which gave all objects only a sixth of their terrestrial weight — compensated for much. As the scientists began to accumulate their results and specimens, the radio and TV circuits with Earth became busier and busier, until they were in continuous operation. We were taking no chances; even if *we* didn't get home, the knowledge we were gathering would do so.

The first of the automatic supply rockets landed two days before sunset, precisely according to plan. We saw its braking jets flame briefly against the stars, then blast again a few seconds before touchdown. The actual landing was hidden from us, since for safety reasons the dropping ground was three miles from the base. And on the moon three miles is well over the curve of the horizon.

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When we got to the robot, it was standing slightly askew on its tripod shock absorbers, but in perfect condition. So was everything aboard it, from instruments to food. We carried the stores back to base in triumph and had a celebration that was really rather overdue. The men had been working too hard and could do with some relaxation.

Then we turned our minds to competitive sports, but found that, for obvious reasons, outdoor activities were somewhat restricted. Games like croquet or bowls would have been practical had we had the equipment; but cricket and football were definitely out. In that gravity, even a football would go half a mile if it were given a good kick — and a cricket ball would never be seen again.

Professor Trevor Williams was the first person to think of a practical lunar sport. He was our astronomer and also one of the youngest men ever to be made a Fellow of the Royal Society, being only thirty when this ultimate accolade was conferred upon him. His work on methods of interplanetary navigation had made him world famous; less well known, however, was his skill as a toxophilite. For two years in succession he had been archery champion for Wales. I was not surprised, therefore, when I discovered him shooting at a target propped up on a pile of lunar slag.

The bow was a curious one, strung with steel control wire and shaped from a laminated plastic bar. I wondered where Trevor had got hold of it, then remembered that the robot freight rocket had now been cannibalized and bits of it were appearing in all sorts of unexpected places. The arrows, however, were the really interesting feature. To give them stability on the airless moon, where, of course, feathers would be useless, Trevor had managed to rifle them. There was a little gadget on the bow that set them spinning, like bullets, when they were fired, so that they kept on course when they left the bow.

Even with this rather makeshift equipment, it was possible to shoot a mile if one wished to. However, Trevor didn't want to waste arrows, which were not easy to make; he was more interested in seeing the sort of accuracy he could get. It was uncanny to watch the almost flat trajectory of the arrows; they seemed to be traveling parallel with the ground. If he wasn't careful, someone warned Trevor, his arrows might become lunar satellites and hit him in the back when they completed their orbit.

The second supply rocket arrived the next day, but this time things didn't go according to plan. It made a perfect touchdown, but unfortunately the radar-controlled automatic pilot made one of those mistakes that such simple-minded machines delight in doing. It spotted the only really unclimbable hill in the neighborhood, locked its beam onto the summit of it, and settled down there like an eagle descending upon its mountain aerie.

Our badly needed supplies were five hundred feet above our heads, and in a few hours night would be falling. What was to be done?

About fifteen people made the same suggestion at once, and for the next few minutes there was a great scurrying about as we rounded up all the nylon line on the base. Soon there was more than a thousand yards of it coiled in neat loops at Trevor's feet, while we all waited expectantly. He tied one end to his arrow, drew the bow, and aimed it experimentally straight toward the stars. The arrow rose a little more than half the height of the cliff; then the weight of the line pulled it back.

"Sorry," said Trevor. "I just can't make it. And don't forget — we'd have to send up some kind of grapnel as well, if we wanted the end to stay up there."

There was much gloom for the next few minutes, as we watched the coils of line fall slowly back from the sky. The situation was really somewhat absurd. In our ships we had enough energy to carry us a quarter of a million miles from the moon — yet we were baffled by a puny little cliff. If we had time, we could probably find a way up to the top from the other side of the hill, but that would mean traveling several miles. It would be dangerous, and might well be impossible, during the few hours of daylight that were left.

Scientists are never baffled for long, and too many ingenious (sometimes over-ingenious) minds were working on the problem for it to remain unresolved. But this time it was a little more difficult, and only three people got the answer simultaneously. Trevor thought it over, then said non-committally, "Well, it's worth trying."

The preparations took a little while, and we were all watching anxiously as the rays of the sinking sun crept higher and higher up the sheer cliff looming above us. Even if Trevor could get a line and grapnel up there, I thought to myself, it would not be easy making the ascent while encumbered with a space suit. I have no head for heights and was glad that several mountaineering enthusiasts had already volunteered for the job.

At last everything was ready. The line had been carefully arranged so that it would lift from the ground with the minimum of hindrance. A light grapnel had been attached to the line a few feet behind the arrow; we hoped that it would catch in the rocks up there and wouldn't let us down — all too literally — when we put our trust in it.

This time, however, Trevor was not using a single arrow. He attached four to the line, at two-hundred-yard intervals. And I shall never forget that incongruous spectacle of the space-suited figure, gleaming in the last rays of the setting sun, as it drew its bow against the sky.

The arrow sped toward the stars, and before it had lifted more than fifty feet Trevor was already fitting the second one to his improvised bow. It raced after its predecessor, carrying the other end of the long loop that was now being hoisted into space. Almost at once the third followed, lifting its section of line — and I swear that the fourth arrow, with its section, was on the way before the first had noticeably slackened its momentum.

Now that there was no question of a single arrow's lifting the entire length of line, it was not hard to reach the required altitude. The first two times the grapnel fell back; then it caught firmly somewhere up on the hidden plateau — and the first volunteer began to haul himself up the line. It was true that he weighed only about thirty pounds in this low gravity, but there was still a long way to fall.

He didn't. The stores in the freight rocket started coming down the cliff within the next hour, and everything essential had been lowered before nightfall. I must confess, however, that my satisfaction was considerably abated when one of the engineers proudly showed me the mouth organ he had had sent from Earth. Even then I felt certain that we would all be very tired of that instrument before the long lunar night had ended . . . .

But that, of course, was hardly Trevor's fault. As we walked back to the ship together, through the great pools of shadow that were flowing swiftly over the plain, he made a proposal that, I am sure, has puzzled thousands of people ever since the detailed maps of the first lunar expedition were published.

After all, it does seem a little odd that a flat and lifeless plain, broken by a single small mountain, should now be labeled on all the charts of the moon as Sherwood Forest.

Camera in the science lab

Photography is the researcher's number one recording tool. Why not use it in your experiments?

When Hillary reached the peak of Mount Everest one of the first things he did was to put his nearly frostbitten fingers to work snapping the shutter of a 35-mm. camera.

The reason? Photography plays a major role in all modern scientific endeavor. On their recent historic expedition, trans-antarctic explorers made a photo-record of everything they could see in the polar night. Time-lapse movies have given botanists new insights into plant behavior. Missilemen take color pictures to record the performance of their birds miles above the earth. And when man himself goes out into space, it's a dead certainty he'll take his cameras with him.

It's just as certain that photography can make your own experiments more interesting and meaningful.

For some experiments, you don't even need a camera. You take "photograms." A photogram makes use of the basic quality of photographic paper: its sensitivity to light.

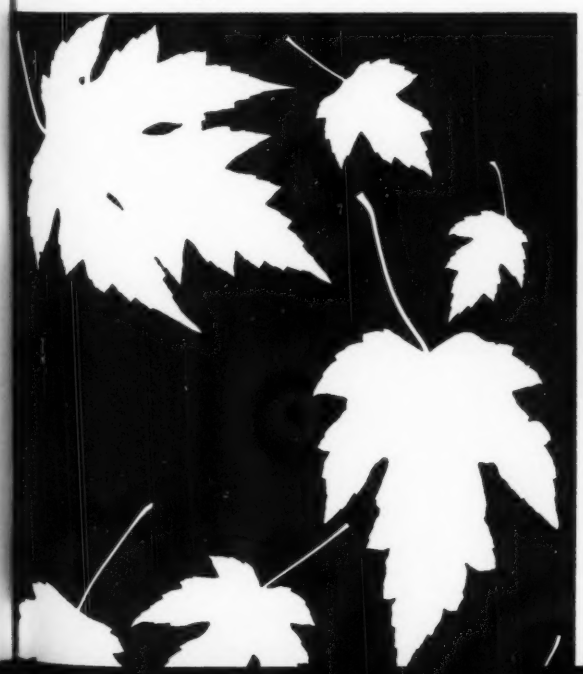
A lot can be done with photograms. As a starter, you might make a photogram showing a magnet's lines of force. First, place a piece of photographic paper on top of a bar magnet. You can work in subdued room light, if you use a paper that is not very sensitive to incandescent light. Kodak Velite Paper, for example, is not affected by the light of a 60-watt incandescent lamp, provided that the lamp is kept four feet or more from the paper.

With the paper resting on the bar magnet, sprinkle iron filings on the paper's surface. Direct a 100-watt light on the paper for about 15 seconds from a distance of about 8 inches. Brush off the iron filings and develop the paper with one of the Kodak Tri-Chem Packs (available for 35 cents in drugstores and camera shops).

On the finished photogram, the magnetic lines of force will appear as a cluster of lines at each pole and as arcs between the poles. In other experiments you can show how like poles repel one another and unlike poles attract. Just use two magnets and follow the same procedure.

Traceries of white lines on photograms will make other experiments graphic. The outline of a leaf can be recorded by placing the leaf on photo paper and exposing to strong light for about 15 seconds. Variations on this theme can provide you with accurate measurements of plant or leaf growth over a period of hours or days.

More ambitious is a photogram record of the growth of a bacteria or mold culture. Here, the paper is placed under a Petri dish containing nutrient solution and a culture. From time to time, light from an electric bulb is focused on the dish to trace the growth patterns on the photo paper. For test-



NO CAMERA IS NEEDED for some photographic experiments. Photogram of leaves (*left*) was made by placing leaves on photographic paper (*above*), then exposing them to the light of a 100-watt lamp for about 15 seconds. Photograms can be used in plant-growth experiments.

ing the effectiveness of different nutrients or the rate of growth of one culture against another, this method is unbeatable.

The things you can do with a piece of photo paper are remarkable. But when you put a roll of light-sensitive film in even a snapshot camera, photography's scientific potentialities increase fiftyfold.

With a $10 camera you can make photographs through a microscope. Determining the right exposure and the proper placement of the camera above the microscope's eyepiece takes some experimentation. A piece of plain white paper can cut short some of the trial and error in finding the best distance above the eyepiece to place the camera. Here's how:

Arrange the microscope, light, and subject for good viewing. Hold the paper above the eyepiece. The illumination coming through the scope will show as a circle of light on the paper. The circle will vary in size, according to the distance of the paper above the eyepiece. Find the position where this light circle is smallest. That's the best position for the front surface of your camera lens.

In photomicrography, the greater the magnification, the more light is necessary. About 100 times as much exposure is needed to photograph an object at 100 diameters as to record a 10 times magnification. A photoflood or flash lamp may be used in place of a microscope light for cameras having no provision for long exposures. If the camera can be set for a time — or long — exposure, the job is easier. Of course, a tripod ring stand or some other fixed support for the camera is needed.

From pictures taken through a microscope, it's an easy transition to photographs of distant stars. Star trails can be traced in a half-hour exposure without a telescope. Use a tripod or other steady support. Load the camera with medium- or high-speed film, and open the lens for from 15 minutes to several hours. If the North Star is included, it will appear on the film in a nearly fixed position. Other stars will show as arcs, their length depending on the length of the exposure.

Photographs may also be made through telescopes. For the moon, almost any telescope may be used. For stars, planets, and nebula, a "guided" telescope, which can follow the motion of the subject, is needed.

An adjustable camera, fast film, and some advance reading may help you capture on film some of the satellites that man has put into space. The camera lens should be an inch or more in diameter. You'll find satellites elusive, however. They are as hard to catch with a camera, one scientists has said, "as a golf ball at 30,000 feet."

First thing you need to know, of course, is when one of the man-made moons will be overhead. This information may be available in your newspaper or, by telephone, from one of the "moonwatching" teams located in about 100 different communities. Pick a high location, as far as possible from city lights. Set up the camera on a tripod, open the camera lens as far as it will go, and prepare for a time exposure. Then it's a question of watch and wait. When the satellite shoots overhead, aim the camera and take a time exposure of a minute or two. With skill and a cloudless sky, you'll come up with a picture that shows the satellite as a streak across the heavens.

The black of night may be the best time to "shoot" sputniks outdoors, but the brightest sunlight has effects that can be studied in the laboratory. Any still camera can be used to make a series of pictures showing the response of plant life to sunshine. For example, bean sprouts or other rapidly growing plant life placed near a window can be photographed every few hours. The resulting sequence of photographs will illustrate how growing things turn toward sunlight.

A simple movie camera is an effective substitute for high-priced equipment in making time-lapse motion pictures. These can show a flower unfolding or the growth of root structure. Set up a movie camera, and shoot one or two frames every hour or two. If the camera has no simple frame release, just flick the regular release to expose one or two frames. You'll need a photoflood lamp or two to turn on when each exposure is made. When projected at the normal speed of 16 frames a second, the film has a startling effect.

With a close-up attachment — generally deemed invaluable in home or classroom laboratory work — the movie or still camera can record interesting sequences: mold growth, the movement of small living things such as hydra, and such developments from one stage to another as the metamorphosis of a caterpillar into a butterfly or an egg into a chicken. Often these pictures can be made through the small tripod magnifiers found in most biology classrooms.

Various measuring devices add meaning to sequence pictures showing changes in living things. Put a ruler in your pictures of plant growth, or make a grid against which size differences can be measured. In time-lapse movies, a timing device helps, too. You

Yours for the asking

Amateur photographers will find valuable how-to-do-it tips in two pamphlets from Eastman Kodak Company. *Darkroom Design for Amateur Photographers* suggests several plans for temporary and permanent working arrangements — with diagrams and precise measurements to follow. *Photograms by Simple Means* gives illustrations and description of step-by-step procedure for this interesting process. Check No. 3101 or No. 3102.

Literature on careers in meteorology (single copies only) and source references on construction of weather instruments are available by writing directly to: American Meteorological Society, 3 Joy Street, Boston 8, Mass. (*Note: Do not use coupon to request this material.*)

Check your choice, clip coupon, and mail to: **Yours for the Asking, Science World, 575 Madison Avenue, New York 22, N. Y.**

☐ 3101 Darkroom Design for Amateur Photographers

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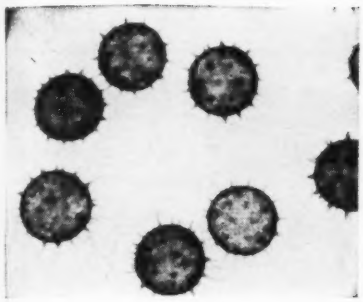


POLLEN GRAINS of hibiscus, magnified to 200 diameters (*above*), were photographed through a microscope. Adapters to link camera lens to microscope are available for several types of 35-mm. cameras. With them, it's possible to make black-and-white or color slide records of lab experiments (*right*).

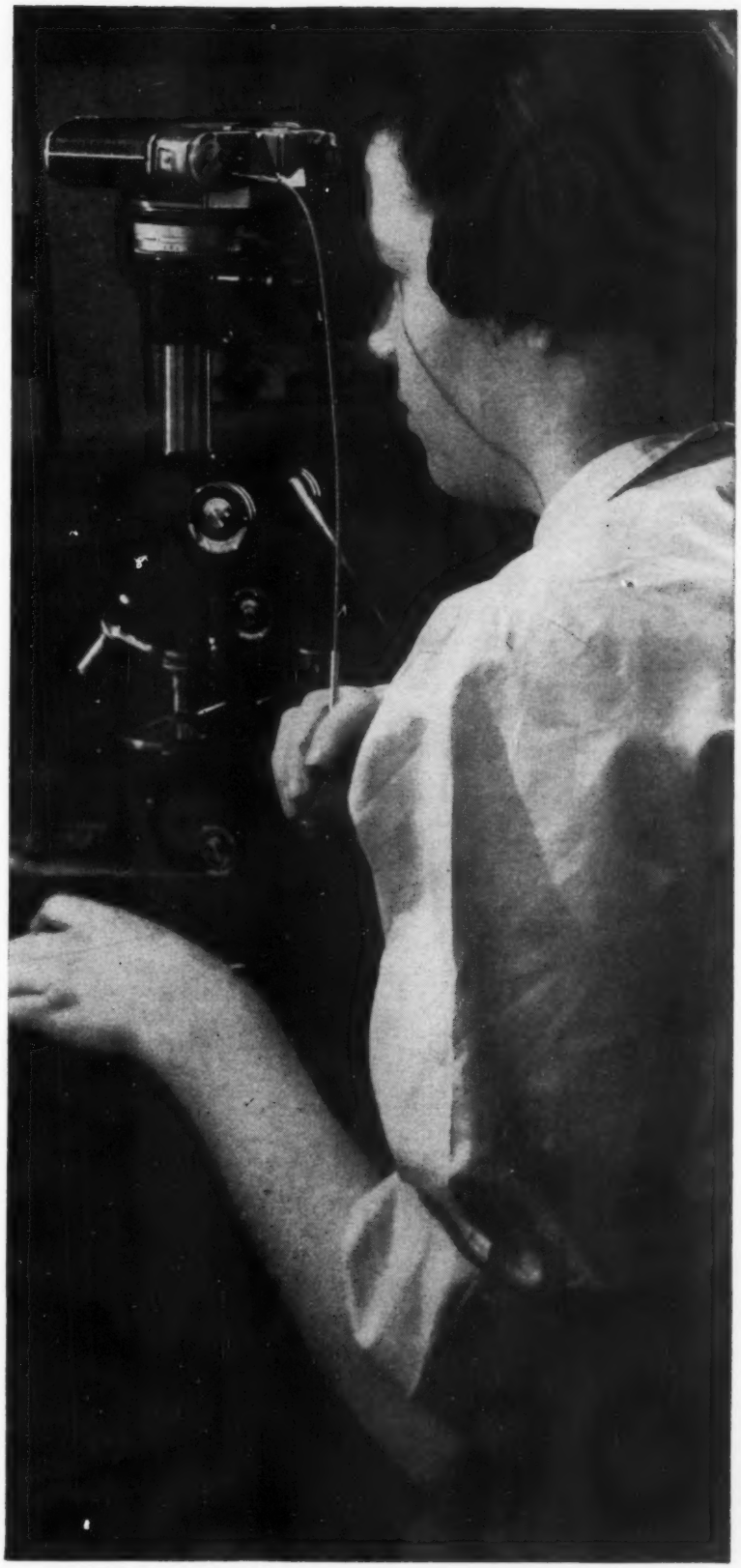
can use a stop watch for rapid sequences, a clock to show change over a period of hours, or a calendar for illustrating longer periods of time.

The action of gravity can be demonstrated by pictures of objects dropping through the air or balls rolling down an inclined plane, each against a background measuring device. Movies taken at your camera's fastest speed and slowed in projection will let your viewers gauge an object's fall or a ball's roll against the action of a stop watch's sweep second hand.

The fascinating field of radioactivity offers additional opportunities for photographic experimentation. A piece of low-grade uranium ore in contact with a sheet of radiographic film can be left in a dark closet for several days. After development — in the same solutions you use for ordinary photographs — the film will show an image caused by radioactivity. Leaves that have been nourished on fertilizers containing radioactive agents can be pressed in the dark against X-ray film to take their own pictures.

A major emphasis in photography today is on color. Color slides of geological specimens can be projected to a greatly enlarged size for showing to fellow students. Some teachers, students, and independent researchers keep color-slide records of each stage in an important experiment. Color pictures are especially helpful in recording changes in animals due to nutritional deficiencies. The pigment in a rat's eye or the skin of an amphibian, for instance, may change with its diet. Color film can record such events.

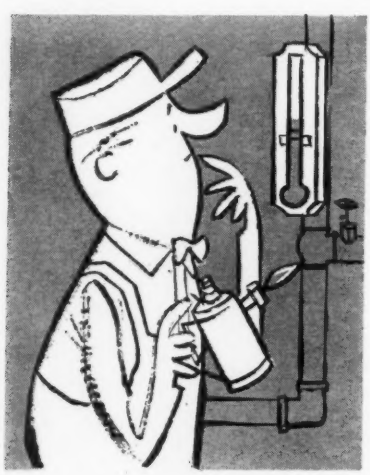
A camera in the science lab can open new horizons for you.



Chuck McComas of Cincinnati, Ohio, writes:

What makes the mercury in a thermometer go up and down?

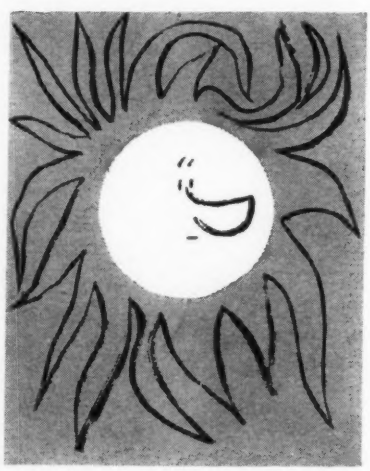
Changes in temperature, which cause the mercury to expand or contract. Mercury has a peculiar property. It is the only common metal that is liquid at room temperature. But, like other metals, it responds to changes in heat by expanding or contracting. As the temperature rises, mercury in the bulb at the bottom of a glass tube expands and travels up the tube. As the temperature falls, the mercury contracts — and down goes the thermometer.



Paul Dombrowski of Clairton, Pennsylvania, writes:

What simple, inexpensive rocket fuel should be used to launch a small rocket?

Rocket launching is extremely dangerous except under expert and adult supervision. Many states have banned amateur rocket firings because of the alarming number of injuries, some of them fatal. In some localities it is illegal to use, or even possess, chemical substances that are potentially explosive. Before you plan any rocket launchings, check the legal requirements in your community and arrange for proper supervision of your experiment by a qualified expert in the field of rocketry. He will help you choose a fuel. You can find out how to go about this by writing directly to: The American Rocket Society, 500 Fifth Avenue, New York 36, N.Y. The U.S. Army also offers information on safe rocket-launching experiments for amateurs. Write: Captain Bertrand R. Brinley, Headquarters, First U.S. Army Information Section, Bldg. A-6, Governors Island, New York 4, N.Y.



Sherri Gene Roush of Kansas City, asks:

What causes sunspots on the sun? How large are they?

These strange, dark patches on the sun's surface have puzzled atronomers for centuries. Scientists think they are the result of gases that have boiled up from the interior to the photosphere (or surface) of the sun. Then, scientists believe, when they break through, their tops cool to a lower temperature than that of the photosphere, and they appear as dark spots on a light background. Sunspots may range in size from a few hundred miles to many thousands of miles in diameter. In 1947, a photograph was taken of a sunspot that covered an area of more than six billion square miles.

Richard Dupuis of Sault Ste. Marie, Ontario, Canada, writes:

How do mirrors work?

There are two parts to this answer. One has to do with light rays. The other has to do with the way a mirror is constructed.

When rays of light strike the surface of an object, they are reflected. Most objects are visible to us because of the light reflected back to our eyes. (Exception: an object that is its own source of light.)

When you stand in front of a mirror, light rays are reflected from your body. They strike the mirror and are reflected to the eye, where they form an image.

This happens because of the way a mirror is made. There are many kinds of mirrors. The common home mirror consists of a sheet of plate glass. One side of the glass is coated with metal (usually silver) or some other material that acts as a reflecting surface. The smooth surfaces of these plane mirrors give off regular reflections — that is, reflections in which light rays are parallel to one another. The light rays are reflected just as they were received, with little change in their character or in their relationship to one another. Therefore, the image matches its object — in this case, you.

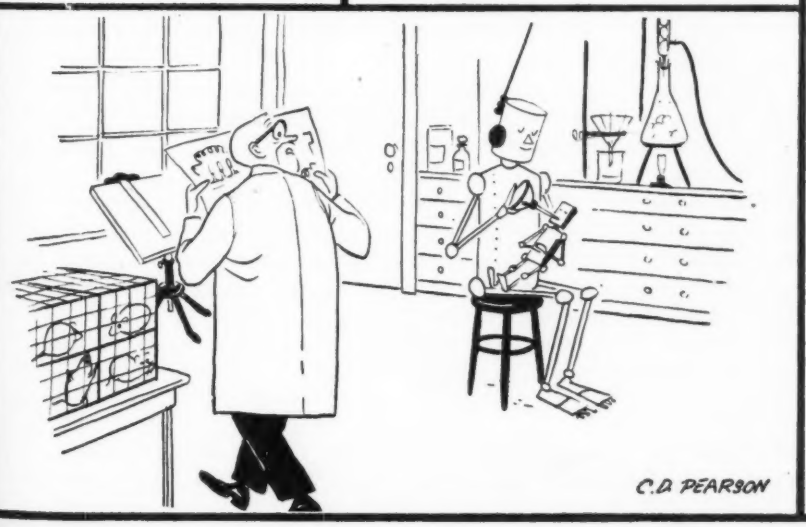
If the smooth surface of a mirror is not a plane, but is concave, convex, or wavy (as in a fun house), the reflected light rays are not parallel to one another. Then a different sort of image is reflected to the eye.

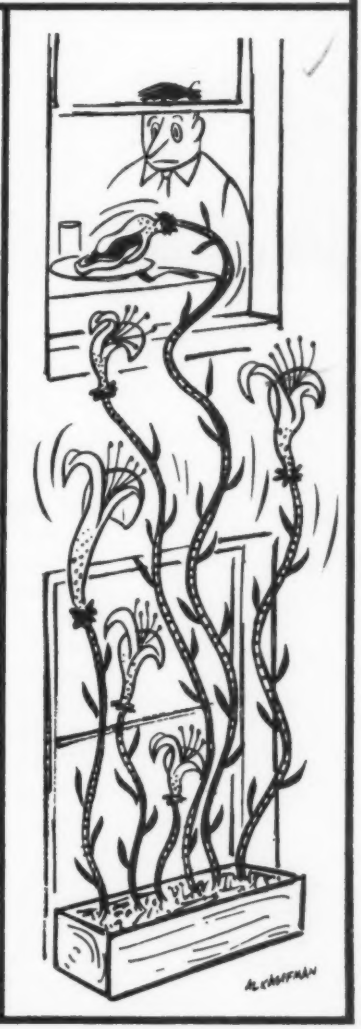
Questions from readers will be answered here, as space permits. Send to: Question Box, Science World, 575 Madison Avenue, New York 22, N.Y.

Jest for fun

"It says, 'Sorry — no can do.'"

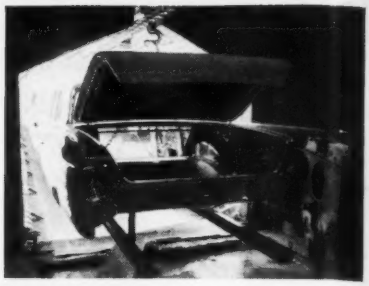
"Well, don't just stand there — clean his windshield!"





THE SCIENCE OF CARS

Diamond Lustre even resists oxidation of a direct flame as this laboratory test shows.



Before Diamond Lustre is applied, the body steel is cleaned, coated with primer and dried.

Three coats of primer are used: each one is polished before being sprayed with another coat.

Finally, Diamond Lustre is sprayed over this base and then baked to a high-gloss hardness.

Tougher 'n Trigonometry!

From Ford Research—a New Enamel Not Even Fazed By This Fire Test

The paint on the body of a car is more than colorful decoration . . . its primary purpose is protection . . . to shield body steel from water, salt, and heat which cause rust and corrosion.

When you look at it this way, you begin to appreciate the giant step forward in paint research and development made by Ford Motor Company's new Diamond Lustre Enamel. Laboratory and road tests have proven it doesn't chip, peel or fade under conditions that would ruin ordinary lacquer finishes like those being used on many of today's new cars. And, an added bonus, Diamond Lustre is so tough it doesn't need waxing or polishing to keep its wet-look lustre.

What makes it so tough? First—it is enamel. Second—the way it's applied: *Three* primer coats to bond paint to metal—next Diamond Lustre is sprayed on—and then the finish is thoroughly *baked* dry in car-sized ovens.

The result: a finish tougher than trig—another of the added value features developed in our Research and Engineering Center for the Ford Family of Fine Cars.

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FORD MOTOR COMPANY THE AMERICAN ROAD, DEARBORN, MICHIGAN

TEACHER'S TOOLS

Because of lack of space, "Teacher's Tools" was omitted from the February 24 issue of STW. *That column is therefore included in "Tools" for this issue.*

WEBER SHOWCASE & FIXTURE COMPANY's Laboratory Equipment Division features the modular concept in the laboratory furniture it produces for modern science classrooms. Modular construction makes it possible to adapt basic units to a new or remodeled science laboratory as though they were custom made. Because the units are standard, there is a considerable saving of money. This laboratory equipment manufacturer's "plan-to-installation" service should interest you. According to Weber, science educators can simplify their work, save time, and expedite completion of their new teaching facilities by contacting their Weber representative. (*For further information, check No. 310A.*)

FISHER SCIENTIFIC COMPANY announces availability of its new Fisher-Cook Atomic Orbital Board. For the advanced high school chemistry and physics classroom, the Board enables students to build up the periodic series of elements from hydrogen to the trans-uranium metals. This effective and different science aid was developed by Dr. William B. Cook, Chemistry Department Head, Montana State College. Printed circles on the clear plastic top-sheet of the pressure-sensitive "Magic Slate" represent "atomic orbitals." An ordinary pencil can be used to show the arrangement of electrons. When one exercise is finished, the student clears the board and is ready for another. (*Check No. 310B for additional information on the Fisher-Cook Atomic Orbital Board.*)

GENERAL LABORATORY SUPPLY COMPANY offers a complete line of Nalgene Polypropylene Laboratory Ware. From beakers with handles to bottles and carboys, funnels, wash and dispensing bottles, General Laboratory can fill your request. An especially useful and worthwhile Nalgene product is the polypropylene hand pump. Quite an efficient pump, it operates by the lift principle and will deliver two gallons per minute. (*To request catalogue, check No. 310C.*)

BARNSTEAD STILL & STERILIZER COMPANY features an ideal research demineralizer for experimentation and classroom demonstration. The new ion-exchange (Model RE-1) kit provides all the basic materials needed for ion-exchange experiments, with various resins to determine their properties and the principles of demineralization. The kit consists of two Lucite columns mounted on a plastic base, a supply of 12 different resins, and more than 100 pages of technical data compiled by the leading manufacturers of ion-exchange resins. (*For complete details on the entire Barnstead product line of water stills, water baths, autoclaves, purity meters and water demineralizers, check No. 310D.*)

CLAY-ADAMS features a Sexless Torso Model, 44 inches high, mounted on a revolving, well-finished, highly polished wooden base. The model is dissectible into 17 parts, and the physiological relationship of the circulatory, respiratory, digestive, and other systems can be clearly outlined. Clay-Adams' "Durable" torso model series are made of pressed paper with a translucent plastic cover. Each model is supplied with a descriptive key giving more than 500 references to the torso "dissection." Anatomical models of the head, digestive system, lower jaw with teeth, and many other demonstration teaching aids are also available. (*For details about these models, check No. 310E.*)

Modern references and textbook 'tools'

Burgess Publishing Company provides an excellent source of current books on biology and zoology. The company also gives science instructors the opportunity to produce copies of their own texts and lab manuals for their classes. Authors need only guarantee the adoption sale of a 300-copy edition within two years. Biology and zoology listings in the Burgess catalogue include:

Microtechnique: A Student's Guide to Slide-making, by Jones and Carpenter. A guide requiring the student to solve special problems.

Introduction to Science, by Mobberly. Designed for a one-semester course, the book treats fifteen facets of natural science.

A General Biology Manual — Part I, by Kugler and Glawe. A manual designed for a one-semester course for non-science-majors.

A Laboratory and Field Manual of Ornithology, by O. S. Pettingill Jr.

For Burgess' catalogue, write to the company at 426 South Sixth Street, Minneapolis 15, Minn.

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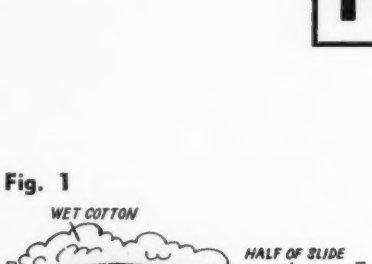
How to do it

Fig. 1



Blood circulation of a goldfish

Here is a way in which students can observe the circulation of blood in the tail of a goldfish:

Materials needed:

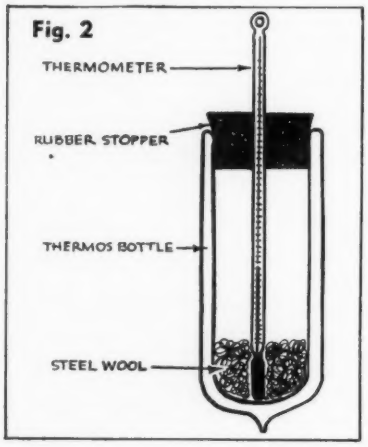
1. Either half of a Petri dish.
2. Two halves of a microscope slide. (Cut the slide across its width and file the cut edges so they won't be sharp.)
3. Two wads of absorbent cotton.

Method (see Fig. 1):

1. Place one of the halves of the slide in the Petri dish.
2. On the opposite side of the dish, spread a *thin* layer of wet absorbent cotton.
3. Place the fish so that its head rests on the wet cotton and its tail rests on the half-slide.
4. Put a thick wet pad of cotton over the head of the fish and the other half-slide over its tail.

The head is now between two wet layers of cotton, the tail between two slides. Place the Petri dish on a microscope stage so that the tail is over the stage opening. Focus the microscope on the circulatory blood. The fish will still be alive even after a half-hour of observation and can be returned to the aquarium.

Fig. 2



Slow oxidation

It's easy to demonstrate oxidation by the rusting of iron filings or steel wool. But it is difficult to convince students that there was any actual oxidation — that there was a release of heat energy, as in ordinary burning. To show this, set up apparatus as in Fig. 2. Wet the steel wool at the bottom of the thermos bottle. In the course of twenty-four hours or less, the thermometer will show a gradual (though very small) increase in temperature. To be sure that the steel wool oxidizes, first wash it in a detergent to remove the protective oil that is put on at the factory. Use plain steel wool, rather than steel wool soap pads.

Putting surface tension to work

Place sealing wax or candle wax in a glass dish or a Petri dish. Embed the head of a needle in the wax, as in Fig. 3. Add ½ inch of water to the dish. From heavyweight aluminum kitchen foil cut a flat propeller-shaped form. Make ¼-inch notches in the propeller, as shown. In each notch place a small piece of gum camphor. (Small blocks of gum camphor are sold in drugstores.) Make a hole in the center of the propeller, and slide it down over the needle so that it rests on the surface of the water. The propeller will spin as the surface tension of the water is broken by the camphor.

Fig. 3

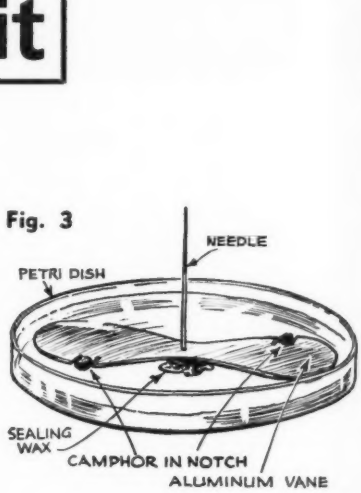
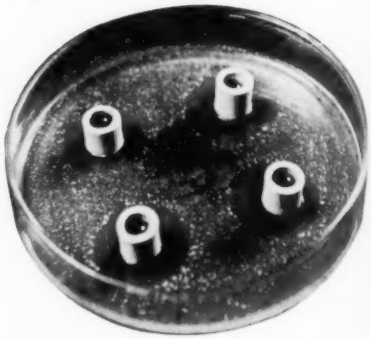


Fig. 4



Making penicillin

The simplest way of making penicillin is to use prune agar as the medium. To prepare the agar, boil about five prunes in water for one hour. Pour off the clear upper liquid. To 200 cc. of this liquid, add 80 gm. of cane sugar and 10 gm. of agar. This quantity (that is, 200 cc. of fluid) will be enough for about seven Petri dishes or

three flasks. For larger amounts, increase all ingredients in proportion.

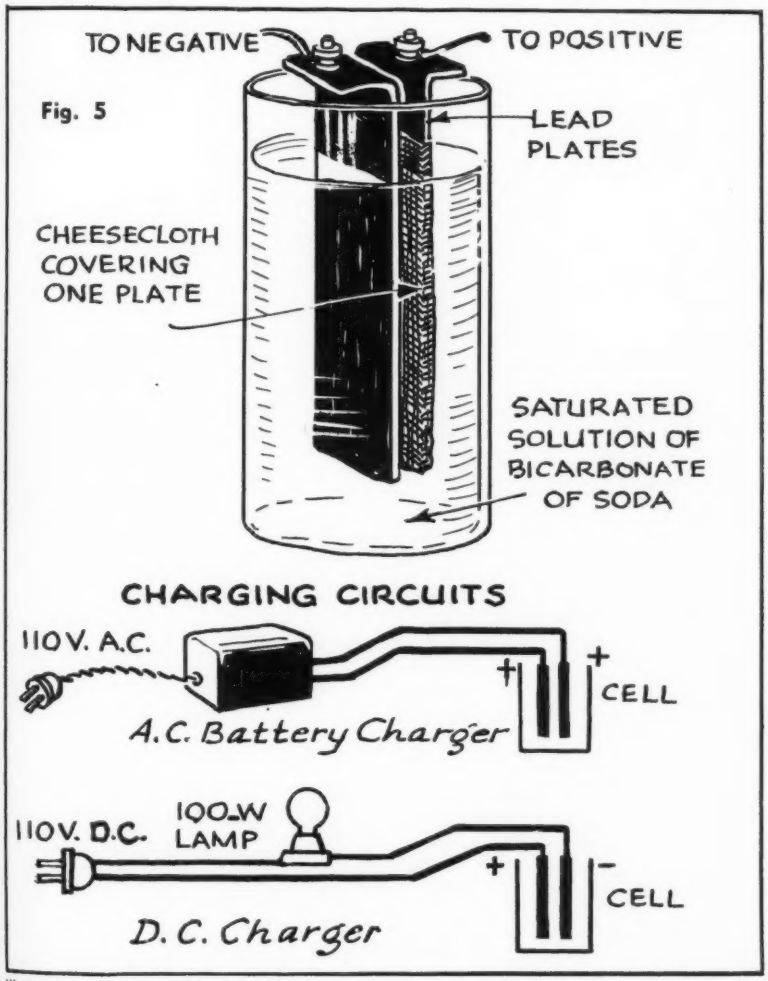
The blue-green mold on Roquefort cheese or citrus fruit is an excellent source of penicillium. In culturing the mold, it is best to keep it on its source. Some teachers prefer to culture the mold in flasks (or in quart milk bottles).

In Fig. 4, the penicillin, a yellow liquid removed from above the mold in a flask, has been placed in half-inch hollow ceramic tubes resting in a Petri dish containing nutrient agar. The cover of the dish has been left off so that bacteria from the air and from dust can collect in it and grow. Notice the circles of inhibition around the tubes, where bacteria do not grow because of the presence of the penicillin. If you do not have these small hollow cylinders, you can cut half-inch circles of filter paper, soak them in penicillin liquid, and use them in the same way.

A simple non-acid storage battery

Here is a type of cell (Fig. 5) that students can make safely. The chemical ingredients cannot harm them or their clothing. The voltage is 1.7 volts per cell. Proceed as follows:

Take two strips of sheet lead about 2 by 8 inches. In each one, punch a hole large enough to receive a small nut and bolt, which will serve as a binding post. Wrap one piece of lead in several layers of cheesecloth or in blotting paper. Then place in a jar containing a concentrated solution of bicarbonate of soda in water. Charge with a battery charger. The plate connected to the positive terminal of the charger will become brown, since it will be oxidized by the oxygen released by electrolysis at the positive pole. The cell can be used to light a 2-volt bulb or to ring a small electric bell.



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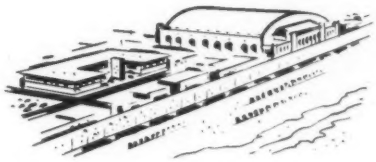

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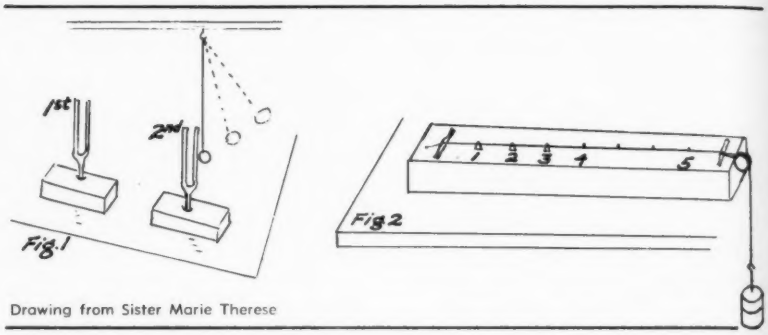
Shop talk

When physics students and music students jointly presented a program on the science and art of music at Manitowoc, Wisconsin, both sides came away with a deeper understanding of the subject. The students were from the physics class of Holy Family Academy and from the music department of Holy Family College. Some highlights of the program, as described by Sister Marie Therese of Holy Family College, were these:

1. A theme song, "There's Music in the Air," was sung to the tones produced by a simple form of the sonometer to illustrate laws of vibrating strings.

2. Characteristics of musical sounds — pitch, loudness, quality — were explained by graphic wave pictures and illustrated by human voice (vibrating membrane), violin (vibrating strings), and bugle (vibrating air column). Physics students explained the theory, and music students illustrated the art.

3. The far-reaching effects of resonance, beats, and forced and sympathetic vibrations were explained and illustrated. A visual aid used to illustrate sympathetic vibrations proved helpful and entertaining. A Ping-pong ball was suspended so that it rested against one of two tuning forks of the same natural frequency. When the first fork was set to vibrating (Fig. 1), the second fork began to vibrate, swinging the Ping-pong ball back and forth. When the vibration of the first fork was stopped, the second fork continued to vibrate, and the Ping-pong ball continued to perform for some time.



Drawing from Sister Marie Therese

4. The physics of harmonics was explained with reference to vibrating air columns. Presented here was the familiar experiment with a simple sonometer to show how a wire vibrates in sections. With a meter stick, a 100-cm. wire was divided into intervals as follows (Fig. 2): interval 1 at 12.5 cm., 2 at 25 cm., 3 at 37.5 cm., 4 at 50 cm., 5 at 87.5 cm. Paper riders were placed at intervals 1, 2, and 3. The wire at 4 was touched with the edge of a ruler and at 5 bowed with a violin bow. The paper riders at 1 and 3 jumped off, while that at 2 remained on the wire, showing the relative positions of the loops and the node.

5. A short history of the musical scales, diatonic and equal tempered, was presented. This explained how the pianist was saved from the ordeal of a seventy-key octave.

6. An oscilloscope was used to record traces of sound waves representing tuning forks of varying frequencies, the human voice, a violin, a flute, and a bugle.

7. The program was closed with two short movies: "The Fundamentals of Sound" and "Science and the Symphony Orchestra."

A success? Well, the physics class at St. Francis Xavier School in nearby Petoskey is looking forward to a unit of this nature during the present school term.

We hope you'll consider "Shop Talk" a combination teacher's room, seminar, and conference round table — a meeting place where all good science teachers can come to the aid of one another by speaking their minds and sharing their experiences. Won't you send us news of unusual classroom experiments, problems, and/or triumphs?

Payments of twenty-five dollars will be made to contributors whose material is used in "Shop Talk." The editors regret that they cannot acknowledge or return unused contributions.

Please send your contributions to this address: Science World Shop Talk, 575 Madison Avenue, New York 22, N. Y.

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